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Early American Observatories*

By WILLIS I. MILHAM

PART I

The Hopkins Observatory of Williams College

The claim is frequently made that astronomy is the oldest of the sciences. If grouping the stars into constellations, if watching the vagrant planets thread their way through the zodiac, if wondering almost in terror whether the setting sun would ever rise again, are to be regarded as the beginnings of this science, then the statement is literally true. This being the case, it is no wonder that Williams College should have paid early attention to Astronomy.

The "Free School" established in Williamstown in 1791 grew into "Williams College" and the first commencement was held in 1795. The first college catalogue ever issued by any American college or university was published by Williams College in 1795. This was a broadside and it was published annually thereafter as a broadside, until 1822 when the catalogue began to be published in pamphlet form and contained, besides the names of the president, trustees, faculty, and students, brief descriptions of the courses given, the texts used, expenses and other information. A perusal of these catalogues during the first thirty-five years (1795-1829) will show that the number of students in all four classes averaged about eighty and the instruction was usually given by five men, the president, two professors, and two tutors. The president was usually professor of intellectual and moral philosophy and perhaps rhetoric as well. One professor was professor of the languages and that meant Latin, Greek, and Hebrew. The other professor was professor of mathematics and natural philosophy and under natural philosophy were grouped astronomy, physics, meteorology, chemistry, biology including botany, and geology including mineralogy. These were not the days of specialization! It was possible for one person to possess not only a general knowledge of but to be master of all the sciences. Later chemistry was sometimes mentioned as a separate subject and the term natural history covering biology including botany and geology including mineralogy was introduced. In the Williams College catalogues the first mention of chemistry comes in 1815, the first mention of mineralogy and botany in 1822, the first mention of natural history in 1825, and the first mention of astronomy in 1830.

*Read at the meeting of the American Astronomical Society at Williams College, Williamstown, Massachusetts, September 8-11, 1937.

A similar arrangement of the instruction existed in most American colleges at the time. They nearly all had a single professor of mathematics and natural philosophy. In Williams College the professorship of mathematics and natural philosophy was founded September 2, 1806. This was the first regular professorship destined to continue for a considerable time and Gamaliel Olds was the first to hold this professorship. He was born in Tolland, then a part of Granville, Massachusetts, February 11, 1777. He was graduated from Williams College in 1801 and held the position of tutor from 1803 to 1805. In 1806 he became professor of mathematics and natural philosophy. He held the position but two years, resigning together with the two tutors on account of difficulties with the president over disciplinary matters.

The story of the development of the sciences in Willams College starts really with that remarkable, versatile, gifted and industrious teacher, Professor Dewey. Chester Dewey was born at Sheffield, Massachusetts, October 25, 1784. He entered Williams College in 1802 and was graduated in 1806. For two years he studied for the ministry and was licensed to preach in 1807. In 1809 he became tutor in Williams College and on September 4, 1810, he became "Professor of Mathematics and Natural Philosophy." In 1815, "Lecturer on Chemistry" was added to his title. In 1825 the title was changed to "Professor of Chemistry and Natural History." In 1827 he resigned his professorship, having served the college well for seventeen years as professor, and became head of the "Pittsfield Gymnasium," a boys' school of high grade, where he remained nine years. He also continued to give instruction in the Berkshire Medical Institution which was connected with Williams College and located in Pittsfield. His title was Professor of Chemistry, Botany, Mineralogy, and Natural Philosophy. In 1836 he removed to Rochester and assumed direction of the "Collegiate Institute." In 1850 when this became the University of Rochester he was appointed Professor of Chemistry and Natural Philosophy. He held this position until 1860 and died December 5, 1867, at the age of eighty-three. He had degrees of B.A. from Williams in 1806, M.A. from Williams and Yale in 1809, M.D. from Yale in 1825, D.D. from Union in 1828, and LL.D. from Williams in 1850.

Natural Philosophy was given during the whole of the Junior year and was of course a required subject. The textbook was Enfield's Natural Philosophy. There is still a copy of Enfield in the college library, bound in leather, dust-covered, and stored away where only the all-knowing library assistants can find it. If one gets it out and turns its pages, from every page comes the cry, dry! dry!! dry!!!—dry as the dust which covers the ancient volume. All credit and honor to the professor who could make such a textbook live and interesting! About a third of Enfield's Natural Philosophy is devoted to Astronomy, and this probably represents the amount of time given to this subject.

To round out the sketch of the versatile Professor Dewey, mention

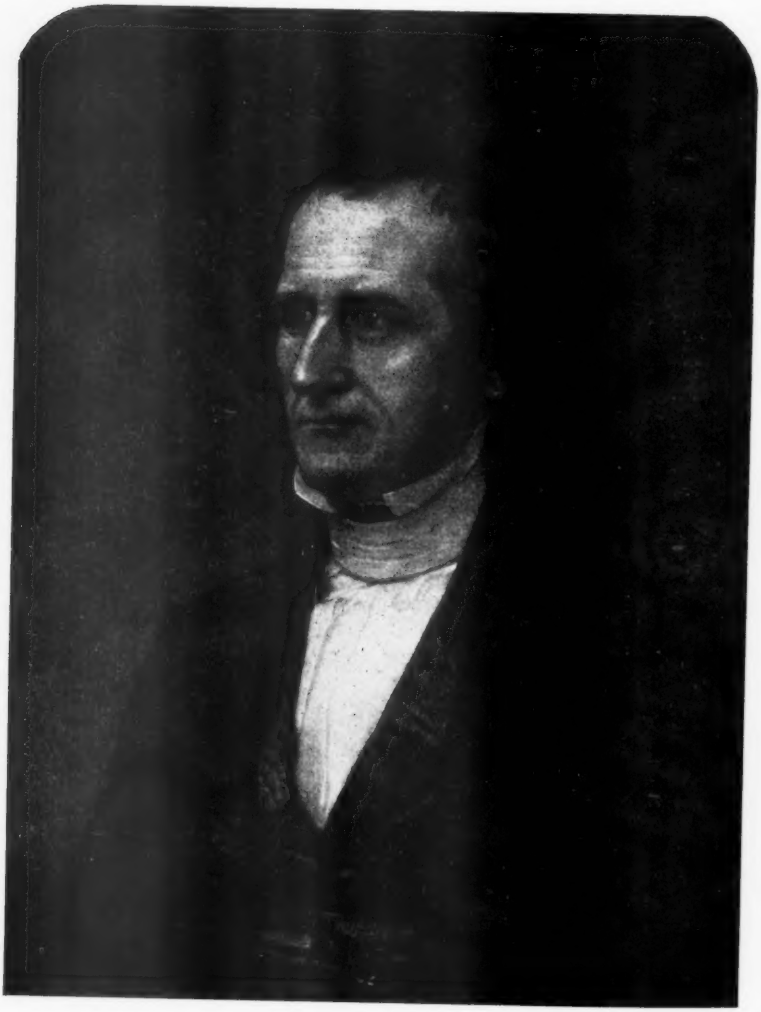
should be made of his executive ability, his acceptability as a preacher, (he was said to have been better liked by the students than the President himself), his energy in giving instruction in Chemistry and getting apparatus for it, and his many writings on biological subjects. He surely covered all the sciences. As regards his personal characteristics it is said of him in one place: "In the lecture room, Dr. Dewey was exact and brief in his statements of principles; clear and full in his illustration of difficulties; sympathetic with the dull in intellect; and patient with the wayward and inattentive. As a colleague, he was uniformly unselfish and courteous."

Chester Dewey's name appears for the last time in the college catalogue of 1826. In the catalogue of 1827 Sylvester Hovey appears as Professor of Mathematics and Natural Philosophy. He was born in 1797 and is spoken of as Sylvester Hovey of Conway. He was graduated from Yale in 1819 and studied for the ministry. He was tutor in Yale College 1822 to 1826. He remained connected with Williams College as professor only two years, resigning to accept a similar professorship at Amherst.

In 1828 Albert Hopkins came to Williams College as Tutor. He was the youngest of the three children of Archibald and Mary Curtis Hopkins, and was born in Stockbridge, Massachusetts, on July 14, 1807. His early boyhood was spent on his father's farm and in attending the district school. His later education was at the Stockbridge Academy, and from there he entered the Sophomore class at Williams College in 1824. He was graduated with the class of 1826 when only 19 years of age, and at commencement delivered the Philosophical Oration entitled "Caloric." After graduation young Hopkins did surveying for a while and considered entering the ministry. In 1828 he was invited to become a tutor in the college, and in 1829 he was made professor, and held this position until his death on May 24, 1872. He was a brother of Mark Hopkins who was president of Williams College from 1836 to 1872.

In June, 1834, it was decided that Albert Hopkins should visit Europe to study the methods of scientific instruction and secure apparatus for this instruction. The Minutes of the Board of Trustees for August, 1834, contain this "Report of Standing Committee":

". . . the sum of $4,000 has been raised by subscription by the Alumni of the college and other liberal patrons of the institution, to be applied to the purchase of Philosophical and Chemical apparatus for the use of the institution, and that it will be necessary to send an Agent to Europe to purchase the same, recommended to the Board that Prof. Albert Hopkins have permission to be absent for that purpose from the 1st day of September next to the first day of May following and that during that time he be allowed his salary as usual he paying all his expenses during his absence." He sailed September 18, 1834, on the packet-ship *Hibernia* for Liverpool and returned the following May. He brought with him quite a little apparatus, particularly astronomical equipment.



ALBERT HOPKINS

It is likely that the older sidereal clock, the Troughton and Simms transit instrument,* and the Herschelian reflector of ten feet focus were purchased at this time. These were not, however, the first astronomical instruments to be possessed by Williams College. The minutes of the Trustees for September 1, 1802, contain this: ". . . to procure a telescope for the college apparatus." This was presumably a small portable telescope to be used in the open for gazing purposes.

In the autumn of that same year, 1835, with the help of the Lyceum of Natural History, he organized the first scientific expedition to be sent out by any educational institution in America. The expedition went to Nova Scotia to study the geology and the flora and fauna of that region. The story of this expedition was written by Professor Albert Hopkins and published in *The American Traveller,* November 13, 17, 20, 1835. The members of the expedition were Albert Hopkins, organizer and leader, Ebenezer Emmons, professor of Natural History, Simeon H. Calhoun, tutor, some fifteen undergraduates and B. F. Mather, merchant of Williamstown.

The next thing was to have a real astronomical observatory. In the autumn of 1836 the quarrying of stone for the observatory commenced and, if the work lagged, it is said that the professor himself worked at stone-cutting with his own hands. In his diary for November 30, 1836, occurs this entry: "Went this afternoon to N. E. Mountain to quarry stone for my observatory." He raised some of the money for the observatory and paid for part of it out of his own pocket. To be exact and prosaic, the records of the trustees show that the observatory cost $2,075, that $1,200 was voted by the trustees, that $400 was contributed by friends, and that Professor Hopkins himself gave $475. The students too helped and in those days they often turned out almost in a body to help build the observatory which was to mean so much to them and the college. Such were the strenuous days of 1837. The stonework of the building was well along in the spring of 1837. An entry in his diary for June 29, 1837, reads: "Finished the stonework of my building today. Felt solemn as the masons left. Felt as though I had not done my duty by them." In the spring of 1838 the observatory was practically finished and it was formally opened with an address by Professor Hopkins on June 12, 1838. A woodcut of the observatory adorns the cover of the college catalogue for 1838-39. Albert Hopkins' title becomes Professor of Natural Philosophy and Astronomy and under observatory, apparatus, etc., appears this modest statement: "The lectures

*Some accredit this transit instrument to Troughton and some to Simms and the spelling is not always the same. A recent apparatus catalogue of Cooke, Troughton & Simms contains these historical statements:

"Of the three names represented in the title of the Firm, that of Troughton is the earliest, his business dating back to the latter part of the seventeenth century. . . . In 1826 the instrument business of William Simms was amalgamated with that of Troughton. . . . Thomas Cooke first began to manufacture refracting telescopes at York in 1836."

in Astronomy are accompanied by celestial observations and instruction in the use of instruments. An observatory has been completed the past season supplying important facilities for these purposes."

The Hopkins Observatory was built of native stone and consists of a central rotunda with two wings. It is surmounted by a revolving dome. The building is 48 feet long and the wings are nearly 14 feet wide. These are outside measurements. The central rotunda is octagonal on the outside and circular on the inside. It has a vaulted ceiling in the form of a hemisphere. This is painted blue and on it gold stars are grouped to form the constellations, and the circles of the celestial sphere are also represented. This is a unique and original idea and reminds one of what is now projected on the inside of a modern planetarium dome. The wings have openings in the walls north and south and roof shutters. In the east wing the Troughton and Simms transit instrument, procured in 1834, turned between two white marble piers. It had a focal length of 50 inches and an aperture of three and a half inches. The Molyneux sidereal clock was placed nearby. The transit instrument continued in position until the building was moved in 1908. What is left of it is now an "antique" and in the "museum" in the rotunda. As far as is known nothing was ever mounted in the west wing. Under the revolving dome was a Herschelian reflector of ten feet focus. What became of this instrument is not certainly known as no trace remains. The records of the Trustees for 1852 contain this interesting item: ". . . that Professor Hopkins may exchange the old telescope for the bones of some animal found in Pennsylvania." Thus the telescope may be reposing somewhere in Pennsylvania as a fossil and some unlabelled Pennsylvanian bones may be reposing somewhere in Williams College. It is not known whether this was the small portable telescope procured in 1802 or the 10-inch Herschelian reflector procured in 1834. At any rate in 1852 the 7-inch refractor which is now in use took the place of the Herschelian reflector. This instrument was procured through the generosity of Amos Lawrence of Boston and has an object glass by Alvan Clark, Sr., and a mounting by Phelps of Troy, New York. Although this was one of Alvan Clark's first object glasses, the instrument was considered at the time a very excellent one. The sidereal clock carries the name Molyneux and Cope, London, across the dial. This firm was in business in London from about 1820 to 1840 and nearly all of the sidereal clocks which came to America during this period were made by them. It is a grandfather clock with a brass movement, a mercury compensation pendulum and an anchor escapement. The hour hand moves over a small dial and the hours are numbered from 1 to 24. It is an excellent clock, still running after a hundred years, and giving a good account of itself.

Professor Elias Loomis in his book "The Recent Progress of Astronomy," copyrighted in 1850, has this to say about the Hopkins Observatory: "In 1836, Professor Hopkins erected a small building, consisting

of a center with two wings, the whole being 48 feet in length by 20 feet in breadth. The central apartment is surmounted by a revolving dome 13 feet in diameter, and each wing has an opening through the roof for meridian instruments. Under the dome has been placed an Herschelian telescope of 10 feet focus, mounted equatorially. The circle for Right Ascension is a foot in diameter; the Declination semicircle is 30 inches in diameter. Both were made by Mr. Phelps of Troy, New York, and read to minutes. In the east wing has been placed a transit instrument by Troughton, having a focus of 50 inches, and an aperture of 3½ inches. In the same room is a compensation clock by Molyneux."

Ralph Waldo Emerson visited the observatory in 1865 and has this to say in his Journal under date of November 14, 1865: "I saw tonight in the observatory, through Alvan Clark's telescope, the Dumb-Bell nebula in the Fox and Goose Constellation; the four double stars in Lyra; the double stars of Castor; the two hundred stars of the Pleiades . . . Mr. Button, Professor Hopkins' assistant, was our star showman, and Stanbrough and Hutton, who have been my committee of the'Adelphic Union,' inviting me here, carried me thither. I have rarely been so much gratified.

"Of all tools, an observatory is the most sublime. And these mountains give an inestimable worth to Williamstown and Massachusetts. But, for the mountains, I don't quite like the proximity of a college and its noisy students. To enjoy the hills as poet, I prefer the simple farmers.

"The dim lanthorn which the astronomer used at first to find his object glasses, etc., seemed to disturb and hinder him, preventing him seeing his heavens, and, though it was turned down lower and lower and lower, he was still impatient, and could not see until it was put out. When it had long been gone, and I looked through the telescope a few times, the little garrett at last grew positively lightsome, and the lamp would have been annoying to all of us.

"What is so good in a college as an observatory? The sublime attaches to the door and to the first stair you ascend;—that this is the road to the stars. Every fixture and instrument in the building, every nail and pin, has a direct reference to the Milky Way, the fixed stars, and the nebulae, and we leave Massachusetts and the Americas and history outside at the door when we come in."

Near the south door of the observatory and in front of Jackson Hall was located the Hopkins sun-dial. It was a marble tablet with a bronze stylus and carried the inscription: "How is it ye do not discern this time." Hawthorne was in this valley during 1838 and, in visiting the marble quarry at the Natural Bridge on Hudson Brook, he saw this same marble tablet which was to support the sun-dial. In his American Note-Books under date of July 31, 1838, he writes: "At one shop for manufacturing marble, I saw a disk of a sun-dial as large as the top of a hogshead; intended for Williams College." After a time the sun-dial

was neglected and fell into disuse and disappeared. It was relocated in the Geology building perhaps used as a specimen of marble. It has been restored and is now placed on Smedley terrace west of the observatory.

Shortly after 1840 observations of terrestrial magnetism began to be made at Williams College as well as at several other institutions. A little octagonal brick magnetic observatory was built near the Hopkins Observatory in 1842. It is not known how long these observations were continued as they were never published and the orginals cannot be found. The college catalogue for 1842-43 contains this statement: ". . . a magnetic observatory has just been completed." The last mention of magnetic observations is in the college catalogue for 1869-70. In the early 70's it was used as a students' room and was called the "hermitage." There was also a small square stone tower in which a bar magnet was suspended and its position was read by means of a view telescope from the Hopkins Observatory. Both of these small buildings were taken down when the new dormitory, Berkshire Hall, was constructed in 1905. The stone slab which held the view telescope is still to be seen on the window sill in the east wing of the observatory.

The first really exact determination of the latitude of the Hopkins Observatory was made by Morley between 1860 and 1865. Edward Williams Morley was born in 1839 and was graduated from Williams College in 1860 as valedictorian of his class. He loved chemistry, the philosophy of Mark Hopkins, and the astronomy of Albert Hopkins. In less than a year after graduation he was making his latitude determinations. Apparently the meridian circle was mounted temporarily in the open in the prime vertical about 100 feet south of the observatory. It is said that he made his own chronograph. It was here under Albert Hopkins that he learned accuracy in observation. His results were communicated to Albert Hopkins and published in the *Proceedings of the American Academy of Arts and Sciences,* January 10, 1865. Morley later became Professor of Natural History and Chemistry at Western Reserve College in Hudson, Ohio. He is chiefly famous for his determinations of the density of oxygen and hydrogen and their combining ratio. Later he carried out in connection with Michelson the well-known ether drift experiments after Western Reserve University had moved to Cleveland.

In 1866 Astronomy at Williams benefited greatly by the generosity of the Field family (chiefly David Dudley Field of the class of 1825) and Professor Hopkins became the first Field Memorial Professor of Astronomy.

In the college catalogue for 1830-31 the word astronomy appeared for the first time. It appeared as a subject taught during the third term of Junior year. The textbook was still Enfield's Natural Philosophy. During the 44 years (1828-1872) that astronomical instruction was given by Professor Hopkins, five textbooks had been used. Enfield's Natural Philosophy continued in use until 1831 when it was replaced by Olmsted's Natural Philosophy. In 1852 Robinson's Astronomy came into

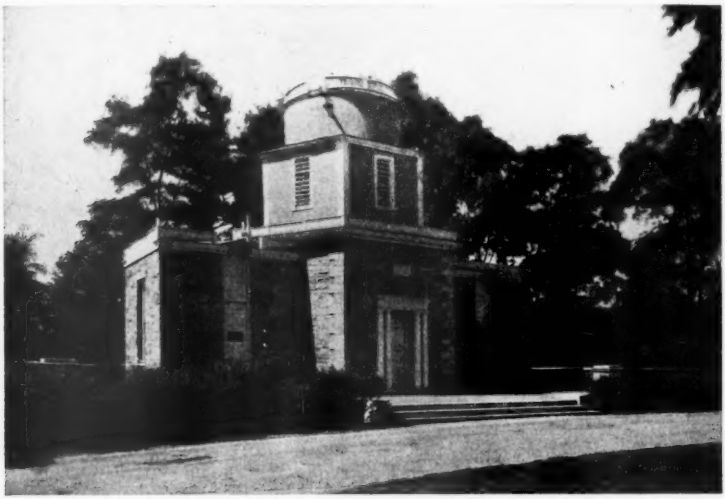
use and this was replaced by Lardner's Astronomy in 1858. In 1867 Loomis's Astronomy was mentioned for the first time as the textbook. All of these have long since been forgotten. At the beginning Astronomy was given as a required subject during the third term of junior year. Later, as the curriculum changed, it was sometimes given during the second term and sometimes during the first and second terms of the senior year as well.

In order to round out the sketch of Albert Hopkins, his religious and philanthropic activities, his love of nature and the out-of-doors, and his personal life should be treated at length. The question is sometimes raised if he was most famous as a teacher, as a preacher, or as a man. He was deeply religious in everything that he did. Over the north door of the observatory was placed this inscription: "Lift up your eyes on high and behold who hath created these." Over the south door was the inscription: "For thus saith the Lord, yet once, it is a little while, and I will shake the heavens, and the earth, and the sea, and the dry land." As regards his personal characteristics it is said of him in one place: "Tall, erect, dignified—with a frame that would have suited an athlete, and a head such as the Greek sculptors gave to their great orator—an eye of unmatched brilliancy."

Next follows an interim of four years during which the Field Memorial Professorship of Astronomy was vacant. During one of these, astronomical instruction was given by Truman Henry Safford as Lecturer in Astronomy, and during two of them by Charles Augustus Young with the same title. This is the famous Professor Young who later became Professor of Astronomy at Princeton and wrote the textbooks so well known to the younger generation of astronomy students. In 1876 Truman Henry Safford was called to become the Field Memorial Professor of Astronomy. He was born at Royalton, Vermont, January 6, 1836, and continued as professor of Astronomy until his death in 1901.

In 1882 the Fields again gave money to Williams College for astronomical purposes. A Repsold meridian circle of $4\frac{1}{2}$ inches aperture was procured. In order to secure a better horizon, the sheet-iron meridian house called the "Field Memorial Observatory" was constructed to house it. Unfortunately it was set upon a clay bank without adequate foundations, and the sheet-iron construction proved only a passing fad. After 1882 Williams College thus possessed two observatories—the Field Memorial Observatory which had just been completed and the Hopkins Observatory which was built 1836-38. Professor Safford was much interested in meridian circle work and thus used the Field Memorial Observatory and rather neglected the Hopkins Observatory. After 1895, due to the poor health of Professor Safford, the Field Memorial Observatory was very little used. In 1908, when new buildings were being constructed on that part of the campus, the Hopkins Observatory was moved bodily a hundred feet or more to the south and turned slight-

ly so as to square it with the campus rather than the universe. This accounts for the rather unusual arrangement of the roof shutters in the east wing. At this time the Hopkins Observatory was renovated and the clock and chronograph and the 2½-inch broken transit by Wanschaff were moved from the Field Memorial Observatory to the Hopkins Observatory and the former became practically an abandoned building. The college sold the site in 1927 and at that time the only remaining instrument, the Repsold Meridian Circle, was removed and stored and the observatory was shortly after demolished, leaving the Hopkins Observatory once more supreme.



THE HOPKINS OBSERVATORY

The Hopkins Observatory is a sturdy, permanent, regular observatory building, not a temporary or makeshift observatory or a mere repository of apparatus which has lasted a hundred years, essentially unaltered and unchanged and is in as good condition now as it was in the beginning. It is celebrating at present the centennial of its existence and is looking confidently toward another hundred years of life.

(To be continued.)

The Brown University Eclipse Expedition to Peru

By CHARLES H. SMILEY

The sole objective of the Brown University Expedition to Northern Peru was the study of the outer corona of the sun at the total solar eclipse of June 8, 1937. It was planned to make visual observations and to secure three photographs of it. A Schmidt camera of four inches aperture and of focal ratio f/1, equipped with an equatorial mount and a clock drive, was the only scientific instrument taken up into the Andes. Thus the expedition was characterized by a minimum of baggage and a singleness of purpose.

On May 9, I sailed from Los Angeles on the *S.S. California* of the Panama-Pacific Line, transferring at Cristobal on May 17 to the *M.S. Virgilio* of the Italian Line which brought me to Callao on May 23. If one were discussing travel, much could be said for the pleasures of this 4,000 mile ocean voyage. Only one thing occurred to mar its perfection; the main spring of my pocket watch broke and I was to learn later that it would be impossible to have it replaced in Peru. It was necessary to purchase a new watch in Lima which fortunately proved to be a good time-keeper.

Mr. Medill McCormick of Albuquerque, New Mexico, who was then in Lima on a tour of South America, was invited to join the expedition as an assistant. He accepted the invitation and served without remuneration. His services as an interpreter and as a general assistant were found to be well-nigh indispensable.

With the kind assistance of Dr. Albert A. Giesecke, the necessary arrangements were made for the trip to the observing site at Callan. Dr. Santiago F. Bedoya, Chief of the Peruvian Diplomatic Service, kindly provided me with a letter requesting all government officials to assist us in every possible way, a letter which proved invaluable on several occasions. Dr. Federico Basadre, Director of the Bureau of Public Works, provided us with a pass for ourselves and our baggage on the government-owned section of the railroad from Tablones to Huallanca. The Geographical Society of Peru graciously placed their facilities at our disposal; we were happy to acquire topographic maps of the region to which we were going.

Since the automobile road from Casma to Huaraz was not yet complete, it seemed best to go north by automobile to the port Chimbote, thence by train inland to Huallanca and on south from there to Huaraz by automobile. On Sunday, May 30, we started on the 300-mile drive from Lima to Chimbote. This road through the coastal desert had been open for only a short time. For long distances we were obliged to travel in second or low gear because of the heavy sand. Frequently the

road was not defined and one went where the going looked good. The first night we spent at Huacho instead of at Barranca as planned. The second day was even longer and more tiresome; we had six flat tires and were stuck in the sand eight times. The flat tires were particularly troublesome since neither of the two jacks with which our automobile was equipped would work. We were supposed to reach Chimbote on the second day, but darkness found us at Huarmey, some sixty miles short of our destination. It was essential that we reach Chimbote by morning since trains left for Huallanca only on Tuesday and Friday mornings. With the assistance of Alcalde Palomino of Huarmey, we were able to have certain needed repairs made on our automobile and to secure a relief driver who drove us all night through the sand hills and brought us to Chimbote in time for the Tuesday train.

Again we must omit details of the interesting trip by narrow-gauge railroad from Chimbote on the coast to Huallanca at an elevation of 5,000 feet, and by automobile from Huallanca to Huaraz at an elevation of 10,000 feet above sea level. A description of the road up the beautiful Huaylas Valley, between the Cordillera Negra and the Cordillera Blanca of the Andes would exhaust the supply of superlatives in the English language. Among the snow-clad peaks on the left is the magnificent Huascaran which is either the second or third highest peak in the Western Hemisphere.

After our arrival in Huaraz, we were aided in countless ways by the Prefect of the Department of Ancash, Senor Manuel Morante. It is a pleasure here to acknowledge his invaluable coöperation. Dr. Gustave Reusens, Director of the School of Arts and Science in Huaraz, assisted us in our preparations for the eclipse, very graciously placing the facilities of his institution at our disposal. Dr. Luis Rivera, Professor of English in the National Women's College, volunteered to serve as an interpreter; his knowledge of the Indian language, Quechua, as well as his fluent command of English and Spanish proved very useful.

An automobile road had just been completed from Huaraz up to Callan, the pass in the Cordillera Negra. It was from this pass, at an elevation of 14,000 feet above sea level that we hoped to observe the eclipse. The first trip up this twenty miles of road and back left me with the severe headache and other symptoms of soroche or mountain sickness. Fortunately after recovering from the first attack, there was no recurrence of it on later trips to the pass.

We were received most hospitably by the prominent citizens of Huaraz. Mention should be made of the party given by Club Huaraz in our honor. Also at the invitation of Senor Nemesis Morales, we spent several days at his hacienda, Canshan, which was at an elevation of 12,000 feet and only about ten miles by automobile road from Callan. The comfort and convenience of our accommodations far exceeded our most optimistic expectations.

After a pier had been built of flat stones and the camera mounted on

its polar axis, it was found that the driving mechanism was out of order and could not be repaired. Thus the eclipse found McCormick sitting on the ground and smoothly turning a small crank thus providing an excellent substitute for the defective clock drive.

For several days before the eclipse, we looked for the sun at 5:18 P.M., the time at which the eclipse was to become total, and each day it was under clouds. On each occasion, the sun appeared in the clear space beneath the clouds about 5:30 P.M. or about ten minutes after totality would be over on the day of the eclipse. It seemed almost certain that we would miss our opportunity to observe and to photograph the total phase by just a few minutes.

Fortunately on the day of the eclipse, the clouds began to thin out early in the afternoon and the sky around the sun was beautifully clear and transparent an hour before totality. There were about eight hundred people, approximately two-thirds of them Indians, up on the pass at the time of the first contact. The Indians became very quiet when the moon's limb began to be seen against the sun's disk; to allay their fears, Dr. Rivera carefully explained exactly what was going to happen. They maintained an awe-stricken silence until the beginning of totality; then they burst forth in almost hysterical clamor, making such an uproar that McCormick could not hear my shouts and we lost thirty valuable seconds of the two hundred two seconds of totality. We had no reason for fear since we were adequately protected by six members of the Civil Guard and a member of the Secret Service.

We could see coronal streamers running out to fine sharp points; these could be seen with the naked eye with certainty for three solar diameters from the limb of the moon and with some uncertainty for four solar diameters. Because of the unexpected brilliance of the corona, both inner and outer, and the splendid transparency of the sky, I decided to use exposures less than the sixty seconds each originally planned. Three exposures were made, all at the full aperture of the camera, f/1; the first fifty seconds on a green-sensitive film especially prepared for us by the Research Department of the Eastman Kodak Company, the second forty seconds on a super-sensitive panchromatic film and the third twenty seconds on a double-coated orthochromatic film. These films were brought back to the United States for development.

Once totality was over, the Indians began to stream back down into the valley. Apparently they were not interested in seeing that the sun recovered its proper shape and size.

By working rapidly, the Schmidt camera and its mount were packed before it was completely dark. After pausing at the Hacienda Canshan to pick up the remainder of our luggage and to say goodbye to our genial host, we drove down to Huaraz and filed our cablegrams to the United States reporting our success. Then we drove all night by automobile, reaching Huallanca about five in the morning. The Prefect,

Senor Morante, had arranged for a special "auto-carril" to take us down the railroad to Chimbote. Reaching there at 11:00 A.M., we took a special plane of the Aero-Faucett Company to Lima. Tired and worn though we were, it was a real pleasure to watch the coastal desert glide along underneath us. In Lima, we celebrated in the afternoon, using soap and hot water in generous quantities.

On June 11, I said goodbye to McCormick and sailed from Callao on the *M.S. Virgilio.* I disembarked at Cristobal on June 16, and waited two days for the arrival of the *S.S. Pennsylvania.* Eight more days of smooth seas and good companions brought me back to Los Angeles.

Upon development, the films showed coronal streamers running out only as far as we had observed them visually. This was something of a disappointment since photographs of stars taken on Mt. Wilson before starting on the trip had shown that exposures of thirty seconds would record stars definitely below naked-eye visibility. However, two of the three films show wedge-shaped regions on either side of the sun, and lying along the ecliptic, faintly brighter than the remaining region around the sun and extending from the visible horizon to the edge of the film, a distance of about twelve degrees. The sun was almost eight degrees above the mathematical horizon, about ten degrees above the ocean horizon. A careful study of the inherent defects of Schmidt cameras and of the particular faults of our own camera and a thorough examination of the negatives seem to indicate that these regions are genuine and are not merely photographic peculiarities. The negative resulting from the twenty second exposure shows densities ranging from 3.5 to 3.9, that is, in the thinner parts of the negative, about one three-thousandth of the incident light passes through.

It is realized that three photographs taken with a single camera at a single eclipse provide very limited evidence on the reality of this phenomenon. It is hoped to photograph the outer corona again at the total solar eclipse of October 1, 1940, from a point in the mountains near Pernambuco, Brazil. With a duration of totality of about 290 seconds and with the eclipsed sun at an altitude of about 54 degrees, it should be possible to secure further evidence.

BROWN UNIVERSITY, PROVIDENCE, RHODE ISLAND, OCTOBER 4, 1937.

E. P. Burrell
1871-1937

By J. S. PLASKETT

The readers of POPULAR ASTRONOMY will be interested to hear something of the attainments and life of the late E. P. Burrell, Director of Engineering of The Warner & Swasey Company of Cleveland. Mr. Burrell was trained at Cornell in engineering and for many years his principal work with the company was in the design and construction of

its well-known line of turret lathes and other machine tools. For the last twenty years, however, an increasing part of his energy has been devoted to the design and supervision of the construction of large reflecting telescopes and it is with this phase of Mr. Burrell's work that this appreciation attempts to deal.

Although the main work of The Warner & Swasey Company has always been the manufacture of turret lathes, their high reputation rests, in great measure, on the making of telescopes, extending back over fifty years to the time when they built the mounting of the 36-inch refractor of the Lick Observatory and ten years later, the 40-inch Yerkes telescope. These two refractors, the largest ever constructed, have never been equalled in skill and ingenuity of design, in accuracy of construc-

E. P. Burrell
1871-1937

tion, and in convenience of operation. As they had reached the useful limit of size in refracting telescopes, there followed a lull in the construction of large telescopes for over twenty years, broken only by the successful construction and operation of the 60-inch reflector at the Mount Wilson Observatory which clearly showed the great superiority of the reflecting over the refracting type for apertures larger than 40 inches.

The Warner & Swasey Company was awarded, by the Canadian government in 1913, the contract for the mounting of a 72-inch reflecting telescope with dome and accessories to be erected at Victoria, B. C., and this gave Mr. Burrell his first opportunity at telescope design. Although the general form of the mounting and some novel features in the design were specified by the writer, and although the symmetry and fine lines of the design were due to Mr. Swasey, the mechanical details were beautifully developed by Mr. Burrell, who showed little less than genius in

working out the operating mechanism in the most efficient and, at the same time, in the simplest possible form. It was the first telescope to have the main axes wholly carried on self-aligning ball bearings and in which all quick and slow motions were electrically operated. This telescope, as yet unsurpassed by any working telescope in simplicity and beauty of design, in accuracy of construction, and in speed and convenience of operation, has been in successful and fruitful use for nearly twenty years and forms a great tribute to Mr. Burrell's outstanding skill in telescope design.

This telescope was shortly afterwards followed by the 69-inch Ohio Wesleyan reflector similar in design to the 72-inch, but the masterpiece of The Warner & Swasey Company and of its designer, Mr. Burrell, is the 82-inch reflecting telescope for the McDonald Observatory in Texas. The specifications laid down for this instrument were very exacting and difficult to fulfill and required the utmost skill and ingenuity and practically unending patience on Mr. Burrell's part to satisfy. The working out of the Coudé form in this type of telescope, the ingenious elevating platforms for observing at the Cassegrain focus in every position as well as for silvering and changing attachments, the simplified arrangements for changing mirrors at the upper end of the tube, and his adaptation of the McMath-Hulburt vacuum tube type of drive, giving any required variation of guiding speed in both right ascension and declination, are some of the novel and ingenious features developed by Mr. Burrell in this instrument.

No man can have a finer monument than these great telescopes for which Mr. Burrell is mainly responsible, nor can any man have a more enduring memorial than that provided by the work they are doing and will continue to do in adding to our knowledge of the Universe. These speak in no uncertain terms of Mr. Burrell's outstanding scientific and engineering ability, but they fail to reflect another and equally rare aspect of his character, his kindly and lovable personality. During the twenty-five years I have known Mr. Burrell, my admiration for his ability and my affection for him have grown with the years. He had unending patience and forbearance with everyone, often severely tried by the none too reasonable demands of astronomers and others, which he tried untiringly to satisfy, yet never once during our long friendship did I see him impatient with, or make an unkind remark about anyone. These qualities endeared him to his colleagues in the company and to his many other friends. They will cherish dearly the memory of his skill and his unremittng perseverance in the solution of his problems, but even more dearly his charity and patience, and his other lovable qualities of mind and heart.

The Two Hundred Fifty Brightest Stars

By FRANK B. LINDSAY

The most evident characteristics of the stars are their numbers, their constancy of position with respect to one another, and their range in apparent brightness. The most brilliant, Sirius, the Dog-Star, is more than a thousand times brighter than the faintest star visible to the unaided eye. And the outlines of the constellations have existed without perceptible change throughout the centuries since men have taken census of the starry hosts above. Yet the number of stars visible without the intervention of telescopes is the surprisingly small figure of 5000. An observer cannot, in fact, see even half of them at one time since the dim ones near the horizon are entirely obscured by the absorption of their light in the earth's atmosphere and dust and fog.

The seeming fixity of the stars upon the overarched celestial hemisphere suggests that they must be almost infinitely remote. Again, their notable differences in brightness may be in consequence of the disposition of the stars in space or derive from an actual variety of intrinsic luminosities. Astronomical research has demonstrated the stupendous and widely varying distances of the stars and confirmed an equally astonishing range in stellar luminosity. At the outset it is necessary to discard common notions of great and small, of near and far, and to construct non-terrestrial scales of distance and brilliancy. For apparent brightnesses give no measure of the true magnitude and disposition of these luminaries.

If the brightness of the faintest stars just visible to the unaided eye be assigned the value unity, the 5000 naked-eye stars can be arranged along an arbitrary scale in multiples of this unit brightness. Except for a dozen of extraordinary brilliancy, none exceeds a hundred units of brightness. In consequence of physiological and psychological conditions for human vision, a star whose brightness is less than the unit intensity chosen fails to be seen at all. The same principle of visual sensation underlies the ordinary classification by magnitudes. Early astronomers divided the stars into six groups of decreasing brightness, so that the members of any magnitude would differ in brilliancy by an equal amount from those of either adjacent group. Thus a standard first-magnitude star seems as much more luminous than an average second-magnitude one as it in turn exceeds in brightness a member of the third class. But since equally noticeable differences in intensity occur through the operation of a constant "light-ratio," the brightnesses of type stars

of successive magnitudes progress as follows:

Star of Magnitude	Units of Brightness
6	1.0
5	2.5
4	6.3
3	15.8
2	39.8
1	100.0

On the adopted scale, the brightness of the full moon equals 263,000 first-magnitude stars. The sun gives as much light as 465,000 full moons, or 122,500,000,000 first-magnitude stars. The stars individually visible to the eye taken all together total only 22,000 units of brightness.

The distance of a star is conveniently expressed in light-years, or the number of years light takes to travel from the star to an observer. Yet light speeds at more than 186,000 miles a second and traverses nearly six million million miles in a year. Sirius is one of the closest stars but it is nearly nine light-years away. Many of the 5000 individually visible stars are centuries of light-years distant.

If each star could be brought in turn as close to the earth as the sun, its luminosity could be compared with the sun's. That experiment, however, would be certainly fatal to the earth and its inhabitants since most of the stars under discussion radiate many times over the solar light and heat. So it is preferable that the stars keep their distance and merely reveal their intrinsic luminosities through calculations based upon apparent brightness. Sirius, again, is found to be twenty-seven times as luminous as the sun and some giant luminaries surpass it many thousand-fold.

Telescopes further reveal that many bright stars are not single individuals but pairs, called binaries, or even multiple systems. Since the observed separation of a couple varies in the course of the mutual revolution of the members about their common center of gravity, the revolution period in years is determined when possible. For slowly moving binaries the angular separation in seconds of arc is about all that can be stated. (There are 360 degrees in a whole circle or 1,296,000 seconds of arc.) Occasionally a binary is merely optical: the members lie in nearly the same direction, one beyond the other. But in the majority of instances double stars are found to pursue a common course through space. Sometimes pairs are too close to be seen separately by even the greatest telescopes and their duplicity can be discovered only through spectroscopic evidence. Such systems, whose periods of revolution are often but a matter of days, are called spectroscopic binaries.

To promote acquaintance with stellar neighbors, a list of two hundred fifty-three brightest stars, which includes those through the third magnitude (to $3^{M}.50$), is given in order of decreasing brightness. For each the relative brightness, luminosity, and distance in light-years have been tabulated. Brightness has been calculated on a scale of unity for a sixth-magnitude star and 100 for a standard first-magnitude one. Lum-

inosity is given in terms of the sun as unity. For eight stars only brightness is stated, since distance and luminosity are as yet unknown:

No. 23 γ Crucis	No. 159 γ Trianguli Australis
No. 32 β Carinae	No. 162 υ Carinae
No. 47 γ Velorum	No. 210 α Pictoris
No. 63 ι Carinae	No. 245 α Doradus

At the left is given the constellation designation of the star, and the special proper name when there is one. Between the columns of light-years and luminosities the letter "b" appears for a binary and "s" for a spectroscopic binary. Sometimes a spectroscopic binary also has a visual companion and then is marked "s, b." The combined brightness of a pair, or multiple system, is given; and underneath, the brightness for each member separately. Individual luminosities are not totalled. A member of a binary which would be visible to the naked eye if off by itself is designated by the repetition of the star's letter and a following numeral in order of decreasing brightness (as alpha-1, alpha-2 in No. 3 of the list). Each companion of less than sixth-magnitude is represented by an asterisk in the brightness column since it does not contribute appreciably to the brightness of the star it accompanies; but its luminosity has been recorded. Two stars, No. 42 δ Velorum and No. 250 ϵ Hydrae, have two such independent companions apiece.

If a star has two dim companions which constitute a sub-system or binary by themselves (also revolving around the principal star or stars), these are labelled "sub-binary companions" and marked by a double asterisk. Four stars of the list have such sub-systems—No. 8 Rigel, No. 20 Regulus, No. 179 ι Ursae Majoris, and No. 249 μ Herculis. Three binaries form sub-systems by having a faint companion revolve about one of the main pair: No. 54 γ Andromedae, No. 103 β Scorpii, and No. 187 β Capricorni.

In the column of remarks, "separation" in seconds of arc (or period in years when known) refers to the principal pair. More remote companions are noted as "distant" so many seconds. Sub-binaries, denoted by the double asterisk, are first recorded as to distance from the principal star and then their mutual separation, or period, is stated. If no period or separation is mentioned, the members of a pair are very close. Finally, three stars, seemingly binaries, are merely optical doubles and each member has its own distance in light-years: No. 106 α Librae, No. 172 β Cygni, and No. 184 δ Herculis.

A Note on the Sources of the Table

Brightness, luminosity, and light-years were obtained from magnitudes taken from the "Catalogue of Bright Stars" by Dr. Frank Schlesinger (Yale University Observatory, 1930) and parallaxes presented in Part I of the "General Catalogue of Stellar Parallaxes, Second Edition," compiled by Dr. Frank Schlesinger and Louise F. Jenkins (Yale University Observatory, 1935). If the trigonometric parallax equalled or exceeded 0".050, it was selected for the calculations of lum-

inosity and distance. Otherwise the spectroscopic parallax was used, since this is more dependable for the great number of stars more remote than those of parallax 0″.050. [See astronomies by F. R. Moulton, page 484 (Macmillan, 1931), J. C. Duncan, page 350 (Third Edition Revised, Harper, 1935), and R. H. Baker, page 372 (Second Edition, third printing, Van Nostrand, 1935).]

The translation of magnitude and parallax into brightness, luminosity, and light-years was made through equations of conversion to be found in the textbooks mentioned above. To facilitate the work, preliminary tables were prepared. In condensed form these were published in POPULAR ASTRONOMY, May, 1936: "Some Conversion Tables for Beginning Students in Astronomy."

THE BRIGHT STARS OF THE FIRST THREE MAGNITUDES

(Arranged in order of decreasing brightness)

THE BRIGHTEST STARS

	Star		Brightness	Light Years		Luminosity	Remarks
1	α CMa	Sirius	1077	8.7	b	27	
			*			.009	period 51 years
2	α Car	Canopus	555	652		77,000	
3	α Cen		238	4.3	b		
		alpha-1	185		s	1.1	
		alpha-2	53		s	.3	period 80 years
		Proxima	*			.00006	distant 2°.2
4	α Ori	Betelgeuse	229 to 83	272		5500 to 2000	varies in a period of 5.8 years
5	α Lyr	Vega	221	27		53	
6	α Aur	Capella	207	46	s, b	142	
			*			.0097	distant 723″
7	α Boo	Arcturus	201	38		96	
8	β Ori	Rigel	184	543	s, b	17,700	
		sub-binary				20	distant 9″
		companions	**			20	
9	α CMi	Procyon	161	11	b	6.7	
			*			.00003	period 40 years

FIRST MAGNITUDE STARS

	Star		Brightness	Light Years		Luminosity	Remarks
10	α Eri	Achernar	145	76		270	
11	β Cen		114	217	s	1,750	
12	α Aql	Altair	111	16		8.9	
13	α Cru	Acrux	98	217	b		
		alpha-1	59		s	904	
		alpha-2	37		s	565	separation 5″
			2			34	distant 89″
14	α Tau	Aldebaran	95	44	b	60	
			*			.001	separation 31″
15	β Gem	Pollux	82	33		29	
16	α Sco	Antares	82	326	s, b	2,830	
			*			22	separation 3″
17	α Vir	Spica	82	136	s	497	
18	α PsA	Fomalhaut	77	24		42	
19	α Cyg	Deneb	74	407	s	3,980	
20	α Leo	Regulus	73	64	b	97	
		sub-binary				.305	distant 176″
		companions	**			.002	separation 3″

BRIGHT SECOND MAGNITUDE STARS

	Star		Bright-ness	Light Years		Luminosity	Remarks
21	β Cru		63	272	s	1,510	
22	α Gem	Castor	58	45	b		
	alpha-1		40		s	26	
	alpha-2		18		s	12	period 300 years
			*		s	.041	distant 73″
23	γ Cru		57		b		
			*				distant 105″
24	ε CMa	Adhara	56	326	b	1,940	
			*			2	distant 8″
25	ε UMa	Alioth	54	49	s	41	
26	o Cet	Mira	53 to 0	251	s, b	1,080 to .8	varies in a period of 331 days
			*			.52	
27	γ Ori	Bellatrix	53	251		1,080	
28	λ Sco	Shaula	53	204	s	711	
29	ε Car		51	326		1,750	

SECOND MAGNITUDE STARS

	Star		Bright-ness	Light Years		Luminosity	Remarks
30	ε Ori	Alnilam	50	407		2,705	
31	β Tau	Nath	49	93		138	
32	β Car	Miaplacidus	48				
33	α TrA		45	130		247	
34	α Per	Mirfak	44	130		242	
35	ζ Ori	Alnitak	43	407	b		
	zeta-1		38			2,050	separation 2″.5
	zeta-2		5			380	
36	η UMa	Alkaid	43	130		240	
37	γ Gem	Alhena	43	53	s	40	
38	ε Sgr	Kaus Australis	42	163		363	
39	α UMa	Dubhe	42	67	s, b	60	
			*			.0145	
40	δ CMa	Wezen	41	407		2,190	
41	β CMa	Mirzam	40	362	s	1,720	
42	δ Vel		39	109	b	151	
			*			2.4	distant 3″
			*			.1	distant 69″
43	θ Sco		38	136		231	
44	β Aur	Menkalinan	36 to 33	48		27 to 25	varies in a period of 4 days
45	β Per	Algol	36 to 13	93	s	103 to 37	
46	α Pav		36	233	s	619	
47	γ Vel		36		b		
	gamma-1		33				separation 41″
	gamma-2		3				
48	α Oph	Ras Alhague	35	45	s	23	
49	σ Sgr	Nunki	35	155		275	
50	α And	Alpheratz	35	72	s	59	
51	α Gru		34	93		97	
52	α Hya	Alphard	34	112		142	
53	ζ UMa	Mizar	34	76	b		
	zeta-1		28		s	52	separation 14″
	zeta-2		6		s	12	
54	γ And	Almach	33	93	b		
	gamma-1		31			87	separation 10″
	gamma-2		2		b	7	
	companion of gamma-2		*			2	period 55 years
55	κ Ori	Saiph	33	543		3,190	

	Star		Bright-ness	Light Years		Luminosity	Remarks
56	α Cas	Schedir	33 to 19	136		200 to 115	varies irregularly
57	λ Vel		33	251		667	
58	α Ari	Hamal	32	71		53	
59	β Leo	Denebola	32	43		19	
60	β Cet	Deneb Kaitos	32	57		34	
61	β Gru		32	217		492	
62	β UMi	Kochab	32	99		96	

DIM SECOND MAGNITUDE STARS

	Star		Bright-ness	Light Years		Luminosity	Remarks
63	ι Car		32				
64	γ Cas		32	93	b	90	
			*			.03	distant 2″
65	θ Cen		31	54		30	
66	ζ Pup		31	815		6,730	
67	γ Leo	Algeiba	31	99	b		period 400 years
		gamma-1	23			72	
		gamma-2	8			24	
68	α UMi	Polaris	30 to 28	251	b	619 to 565	varies in a period of 4 days
			*			2	
69	α CrB	Alphecca	30	62	s	37	
70	γ Cyg	Sadr	30	407		1,600	
71	ε Sco		29	86		69	
72	β And	Mirach	28	86		68	
73	γ Cen		28	102	b		period 203 years
		gamma-1	14			48	
		gamma-2	14			48	
74	β Cas	Caph	27	46		19	
75	γ Dra	Etamin	27	91		72	
76	η CMa	Aludra	27	272		642	
77	α Phe		27	64	s, b	35	
			*			.002	distant 10″
78	β UMa	Merak	27	68		40	
79	δ Ori	Mintaka	27	543	b		
		delta-1	26		s	2,465	separation 53″
		delta-2	1			43	

BRIGHT THIRD MAGNITUDE STARS

	Star		Bright-ness	Light Years		Luminosity	Remarks
80	κ Sco		25	362	s	1,070	
81	ε Peg	Enif	24	172	b	233	
			*			.1	distant 82″
82	δ Sco	Dschubba	24	296	s	692	
83	γ UMa	Phecda	24	62		30	
84	ε Cen		24	272		571	
85	α Peg	Markab	24	93	s	67	
86	δ Leo	Zosma	23	65		33	
87	ε Boo	Izar	23	142	b		
		epsilon-1	21			137	separation 3″
		epsilon-2	2			15	
88	α Cep	Alderamin	23	42		13	
89	β Peg	Scheat	23	130		126	
90	η Oph	Sabik	22	72	b		
		eta-1	13			24	
		eta-2	9			14	
91	κ Vel		22	192	s	268	
92	ε Cyg		22	78	s	43	

	Star		Brightness	Light Years		Luminosity	Remarks
93	η Cen		22	272	s	525	
94	α Lep	Arneb	21	192		254	
95	ζ Oph		21	407	s	1,130	
96	θ Aur		21	88	b	53	
			*			.64	
97	ζ Sgr		21	68	b		period 21 years
		zeta-1	12			17	
		zeta-2	9			14	
98	β Ari	Sharatan	21	52	s	18	
99	β Lib	Zubeneschamali	20	142	s	132	
100	π Pup		20	296		576	

THIRD MAGNITUDE STARS

	Star		Brightness	Light Years		Luminosity	Remarks
101	α Col	Phact	20	148	b	143	
			*			.03	distant 12″
102	α Ser	Unukalhai	20	80		41	
103	β Sco	Graffias	20	466	b		
		beta-1	17		s, b	1,225	separation 14″
		companion of beta-1	*			2	distant 1″
		beta-2	3			167	
104	γ Crv	Gienah	19	136	s	117	
105	α CVn	Cor Caroli	19	91	b		
		alpha-1	17		s	47	separation 20″
		alpha-2	2		s	5	
106	α Lib	Zubenelgenubi	19		b		
		alpha-1	17	62		22	separation 231″
		alpha-2	2	91	s	5	
107	δ Cas	Ruchbah	19	48		16 to 13	
108	γ Aql	Tarazed	19	142		125	
109	β Ara		19	192		229	
110	η Boo	Muphrid	19	33	s	7	
111	υ Sco		19	326	s	661	
112	β Her	Korneforos	19	125	s	97	
113	β Lup		19	272	s	453	
114	α Cet	Menkar	19	109		72	
115	τ Pup		19	130	s	103	
116	β Crv		18	121		87	
117	δ Sgr	Kaus Meridionalis	18	136		111	
118	μ Vel		18	99	b	59	
			*			1.3	distant 2″
119	ι Ori		18	155	s, b	141	
			*			1.3	distant 11″
120	γ Peg	Algenib	18	362		766	
121	δ Cen		18	217		273	
122	ρ Pup		18	204	s	240	
123	η Dra		18	91	b	47	
			*			.43	distant 5″
124	α Lup		18	362	s	752	
125	ι Aur		17	148		125	
126	β Hyi		17	23		3	
127	ι Cen		17	67		25	
128	ζ Per		17	466	b	1,210	
			*			3.4	distant 13″
129	τ Sco		17	362		738	
130	α Tuc		17	136	s	104	
131	γ Vir		17	37	b		period 182 years
		gamma-1	9			4	
		gamma-2	8			4	

	Star		Bright-ness	Light Years		Luminosity	Remarks
132	β Eri	Cursa	17	65		24	
133	α Mus		17	217		258	
134	β Oph	Cebalrae	17	96		50	
135	λ Sgr	Kaus Borealis	17	88		43	
136	γ Lup		17	251	b		period 104 years
		gamma-1	10			200	
		gamma-2	7			140	
137	ε Vir	Vindematrix	17	88		42	
138	β Lep	Nihal	16	121	b	78	
			*			.12	distant 3″
139	ε Per		16	543	s, b	1,585	
			*			12	distant 9″
140	η Tau	Alcyone	16	155	b	129	
			*			8	distant 117″
141	α Ara		16	217		252	
142	δ Cyg		16	86	b	39	
			*			.4	period 321 years
143	δ Cap	Deneb Algedi	16	50	s	13	
144	α Her	Ras Algethi		362	b		
		alpha-1	14 to 7			619 to 297	varies in a period of 120 days
		alpha-2	2		s	75	separation 5″
145	β Dra	Alwaid	16	296	b	457	
			*			.02	distant 4″
146	γ Boo		16	52		14	
147	ζ Her		16	30	b	5	
			*			.18	period 35 years
148	π Sco		16	272	s	381	
149	ζ Tau		16	233	s	280	
150	ζ Aql		16	80	s, b	32	
			*			.008	distant 5″
151	α Hyi		16	41		8	
152	π Sgr		16	172		150	
153	θ Car		15	466	s	1,090	
154	δ Oph	Yed Prior	15	116		68	
155	β TrA		15	40		8	
156	ζ Ara		15	204		204	
157	ζ Cen		15	251	s	308	
158	θ Eri	Acamar	15	102	b		
		theta-1	11		s	36	separation 15″
		theta-2	4			15	
159	γ TrA		15				
160	β Aqr	Sadalsuud	15	407		801	
161	γ Sgr		15	88	s	38	
162	υ Car		15		b		
		upsilon-1	14				separation 5″
		upsilon-2	1				
163	δ Cru		15	192		176	
164	γ Per		15	142	s	96	
165	σ Sco		15	362	s, b	631	
			*			1	distant 20″
166	β Tri		15	72	s	25	
167	β CMi	Gomeisa	15	130	s	81	
168	μ^1 Sco		15	296	s	417	
169	ε Aur		15 to 8	362		619 to 325	varies in a period of 27 years
170	δ Cep		15 to 7	652	b	2,015 to 964	varies in a period of 5 days
			*			35	distant 41″
171	ζ CMa	Furud	15	251	s	297	

Star		Brightness	Light Years		Luminosity	Remarks
172 β Cyg	Albireo	15		b		
beta-1		13	181	s	135	separation 35″ optical
beta-2		2	466		127	
173 κ Oph		15 to 6	64		21 to 8	
174 η Peg		15	136	s	87	
175 δ Per		15	217		223	
176 δ Crv	Algorab	14	99	b	46	
		*			.5	distant 24″
177 o^3 CMa		14	466		1,000	
178 ϵ Leo		14	204		192	
179 ι UMa	Talitha	14	49	b	11	
sub-binary					.008	
companions		**			.003	close
180 ι Sco		14	407	s	752	
181 γ UMi	Pherkad Maj.	14	91	s	37	
182 ψ UMa		14	93		39	
183 γ Gru		14	163		119	
184 δ Her		14	71	s, b	23	
		*			.27	dist. 10″ optical
185 η Sgr		14	172	b	132	
		*			.24	distant 4″
186 γ Hyi		14	192		163	
187 β Cap		14	84	b		
beta-1		13		s	29	separation 205″
beta-2		1			2	
companion of beta-2		*			.055	distant 1″
188 ϵ Gem	Mebsuta	13	326		466	
189 ν Pup		13	142	s	88	
190 α Aqr	Sadalmenelik	13	407		717	
191 γ Eri	Zaurac	13	148		96	
192 μ Gem		13	192		160	
193 η Gem	Propus	13 to 5	251	s, b	270 to 98	varies in a period of 231 days
		*			1.3	distant 1″
194 ϵ Crv		13	142		86	
195 α Ind		13	130		72	
196 μ UMa	Tania Australis	13	121	s	62	
197 β Col	Wazn	13	125		69	
198 ζ Dra		13	181		138	
199 δ Dra		13	116		56	

DIM THIRD MAGNITUDE STARS

Star	Brightness	Light Years		Luminosity	Remarks
200 PCG 4501 Sco	13	142		82	
201 β Mus	13	296	b		
beta-1	8		s	200	separation 1″
beta-2	5			157	
202 θ UMa	13	58	b	14	
	*			.0007	distant 5″
203 σ Pup	12	163	s, b	108	
	*			1.4	distant 22″
204 η Aur	12	251		252	
205 ϵ Lep	12	142		79	
206 ζ Hya	12	142		79	
207 μ Lep	12	163		105	
208 α Lyn	12	125		84	
209 γ Lyr	Sulufat 12	155	s	95	
210 α Pic	12				
211 ϕ Sgr	12	217	s	184	

	Star		Bright-ness	Light Years		Luminosity	Remarks
212	π^3 Ori		12	25		3	
213	μ Cen		12	362		506	
214	β Cep	Alfirk	12	543	b	1,160 to 1,060	
			*			15	distant 14″
215	ν Hya		12	125		61	
216	γ Hya		12	109		45	
217	λ Cen		12	105		42	
218	ϵ Oph	Yed Posterior	12	130		64	
219	κ Cen		12	296	s, b	328	
			*			.28	distant 4″
220	β Phe		12	142	b		
		beta-1	6			38	
		beta-2	6			38	
221	π Her		11	155		90	
222	α Ret		11	136	b	69	
			*			.025	distant 49″
223	θ Aql		11	155	s	89	
224	θ Oph		11	407		609	
225	ζ Cyg		11	217	s	168	
226	ξ Gem		11	55		11	
227	ρ Per		11 to 5	272		263 to 126	varies irregularly
228	γ Phe		11	181	s	117	
229	PGC 1875 Pup		11 to 0	181		117 to 9	varies irregularly
230	N Vel		11 to 5	121		52 to 25	
231	α Cir		11	60	b	13	
			*			.075	distant 16″
232	θ Leo		11	105		39	
233	σ Lib		11	163		95	
234	γ Cep	Errai	11	49		8	
235	η Ser		11	62		13	
236	τ Sgr		11	109	s	41	
237	δ Lup		11	272		256	
238	δ Aql		11	60	s	13	
239	PGC 2739 Car		11	407		571	
240	ϵ Cas		11	296		302	
241	η Ori		11	407	b		
		eta-1	8		s	410	separation 1″
		eta-2	3			161	
242	η Sco		11	49		8	
243	δ UMa	Megrez	11	65		22	
244	ζ Vir		11	74		19	
245	α Dor		10				
246	ι Dra	Ed Asich	10	136		62	
247	ξ Pup		10	652	s	1,430	
248	o UMa		10	148	b	74	
			*			.002	distant 7″
249	μ Her		10	30	b	3	
		sub-binary				.008	distant 33″
		companions	**			.003	period 43 years
250	ϵ Hya		10	272	b		
		epsilon-1	8			200	
		epsilon-2	2			50	period 15 years
			*			12	distant 3″
			*			.04	distant 20″
251	π Hya		10	112		42	
252	λ Ori	Meissa	10	815	b		
		lambda-1	9			1,870	
		lambda-2	1			325	separation 5″
			*			2.2	distant 28″
253	δ And		10	125	b	52	
			*			.02	distant 28″

Colton, California.

A Total Eclipse of the Sun, July 29, 1878*

By JAMES H. FREEMAN

I was a lad of 20 then, herding sheep on a lone ranch thirty miles east of Colorado Springs, on the plains. I learned beforehand that I was on the center line of the approaching total eclipse of the sun. Here are some extracts from my diary written at the time.

Givens & Mitch Sheep Ranch, El Paso County, Colorado.
Sunday, July 28, 1878.

. . . Yesterday morning when the rain cleared up Pikes Peak was covered with fresh snow. Snow on the 27th of July when hundreds of persons are being stricken down with heat.

Monday, July 29, A.D. 1878.

On Givens Sheep Ranch east of Colorado Springs. 7 o'clock in the morning. This morning—the morning of a memorable day to astronomers—the sun slowly climbs up into a perfectly clear and crystal sky. I never felt the heat of the sun so intense. . . . The atmosphere is still quite cool and the heat of the sun feels like the heat of a red-hot stove in a cool room. It burns on one side only. Seems as though it was trying to scatter heat and light enough beforehand to last through the eclipse. . . .

I think I will corral my sheep about 1:00 o'clock and view to the best advantage possible a phenomenon which I may not have the opportunity of witnessing again for a life-time.

I can readily imagine the fear and astonishment that will take possession of the hardy Siberian hunter when pitchy darkness falls on all the country just when it should be getting the lightest. What horror it must bring to his superstitious mind.

Had I wings with the speed of thought I would sail along with the first line of the eclipse across Behring Straits and down through Alaska, watching the Eskimo drop his dinner in fright, or pause with uplifted weapon, as total darkness hid his victim from his view; and then on down through British America, along the Rocky Mountains and over the plains of Colorado and Texas and out into the gulf, watching the consternation of the Indians, Mexicans, and frontier hunters. Surely I would see some laughable sights, and perhaps some sad ones.

Pikes Peak is even now alive with sight-seers, I doubt not, though it looks as meek as it ever did, from here. I know not but a thousand eyes are turned on this plain, gazing over my head, and perhaps, some through powerful glasses are watching me as I write. But I must get

*These impressions received by an intelligent person nearly sixty years ago will be of special interest to those who have had the rather exceptional opportunity of witnessing a total solar eclipse. ED.

up and see where my sheep have gone. They are out of sight.

Sun enters eclipse at 2:15, by our clock.

At 3:15 it looks like a new moon at sunset. It is a strange weird light now and getting dimmer.

3:25. Oh! Oh! What a weird, gloomy sight. 3:26 total. . . . 3:28 Partial. Oh! what a strangely beautiful scene. 3:36 New Moon again, in reversed position, growing larger.

The darkness passed away almost at once when the first ray came down. One moment it was dark as midnight—the next as light as midday. 4:30 left penumbra. All over, and the sun shining clear and hot again.

I brought my sheep in just before it became total and kept them in about fifteen minutes.

The chickens stretched their necks curiously as the sky darkened, turned an eye upward, then ran for the roosts stepping high and awkward. Birds chirruped sadly and the stars came out thickly overhead.

I got on top of the house and enjoyed the spectacle hugely. There was a luminous ring round where the sun ought to have been and the horizon miles away was bright all around showing the limit of the totality. Then a bright ray shot down and the dark shadow glided swiftly off to the southeast. In a few seconds it disappeared over high ridges twenty miles away. It looked like a black carpet sliding over the plains.

I watched the sun carefully through a smoked glass until totality. The light faded slowly until the moment the last of the sun disappeared then darkness dropped suddenly. It disappeared as suddenly when the first ray of light shot down. It seemed dazzling at once, but of course it grew slowly brighter for some minutes, in fact until the moon disappeared entirely. The conditions were perfect for viewing this grand spectacle. The clear crystalline atmosphere here at an altitude of more than six thousand feet above sea level could not be improved on.

It came to me without cost or invitation.

1337 Pine Avenue, Long Beach, California.

Planet Notes for December, 1937

Note: All times unless otherwise stated, are Central Standard Time.

The *Sun* will move almost directly eastward from Scorpius into Sagittarius during December. It will reach its greatest declination south of the equator at midnight on December 21, thus marking the beginning of winter in the northern hemisphere. By the end of the month it will have advanced northward only about one-quarter of a degree from its southernmost point.

The phases of the *Moon* for the month will occur as follows:

New Moon	Dec. 2 at 5	P.M.
First Quarter	10 " 7	P.M.
Full Moon	17 " 1	P.M.
Last Quarter	24 " 8	A.M.

The moon will be nearest the earth on December 17 and farthest from the earth on December 3 and again on December 30.

Mercury will come to a point of greatest eastern elongation on December 12. It will then be only a short distance south of the sun and near this date it will set at nearly the same point on the horizon as the sun and about one hour later. After December 21 it will move rapidly westward toward the sun and set with the sun on December 30, the date of inferior conjunction.

Venus will be west of the sun and moving eastward more rapidly than the sun. At the beginning of the month it will still be visible as the morning star, but by the end of the month it will be lost in the dawn.

Mars will still be sufficiently far to the east of the sun to be observed in the evening sky throughout the month. It will be moving slowly eastward in the constellation Capricornus.

Jupiter will be moving eastward more slowly than the sun and by the end of the month will set so soon after the sun as to be invisible. Its distance from the earth will be increasing during this period.

Saturn will be nearly stationary with reference to the stars during this period. It will be near the meridian at sunset and thus be favorably located for evening observation and study. It will still be near the vernal equinox in a region in which there are no conspicuous stars.

Uranus will have a slow retrograde (westward) motion during the month in the constellation Aries. It will be nearly opposite the sun and consequently it will be above the horizon practically throughout the night.

Neptune will continue to be a morning object during this period. On December 15 its position will be, R.A. $11^h\ 29^m$, Decl. $+4°\ 32'$.

Asteroid Notes

By HUGH S. RICE

Concerning the near approach of Eros to the earth during the coming winter, it is noted that this asteroid comes to opposition on November 27. At that time, it is about at its highest point of declination, and is circumpolar, in Camelopardalis. It then travels, in its apparent path in the sky, in a southward direction roughly, passing into Perseus before the end of December. The magnitude at opposition was calculated to be 8.5; however, as so often is the case with minor planets and also comets, it will probably be a magnitude fainter than predicted. This is based on the following observation by Meyer in Rutherford:

October 9.18 U.T., $\alpha\ 3^h\ 58^m6$; $\delta\ +48°\ 49'$; [Eq. 1937.0]; 11^M.

At former apparitions, the magnitude of Eros has been found to vary in a period of $5^h\ 17^m$, yet no fluctuation was observed by Meyer during several hours of watching at this time.

In January when this asteroid comes nearest the earth, the magnitude will probably be 8.5, on the basis of the observation given, combined with the ephemeris calculations. It will therefore be visible in small telescopes. In early 1938 it will move with comet-like rapidity among the constellations.

Ceres is still visible in November in the sky after sunset, in eastern Capricornus, with about $8^M.7$. Pallas, Juno, and Vesta are not conveniently located.

The following minor planets are favorably placed for observation in medium-sized instruments. They are the remaining bright ones that come to opposition this year. The ephemerides were computed by the *Astronomisches Rechen-Institut* at Berlin-Dahlem, Germany.

EPHEMERIDES OF ASTEROIDS

For 0^h U.T. Equinox of 1925.

932 HOOVERIA (11^M.0)

	α (h m)	δ (° ′)
Nov. 11	4 34.2	+32 24
19	4 25.8	32 48
27	4 16.4	33 0
Dec. 5	4 6.6	32 58
13	3 57.8	32 45
21	3 50.4	+32 25

130 ELEKTRA (9^M.7)

	α (h m)	δ (° ′)
Nov. 11	4 33.9	−14 5
19	4 27.9	14 35
27	4 21.3	14 44
Dec. 5	4 14.8	14 31
13	4 8.8	13 57
21	4 3.8	−13 3

433 EROS

	α (h m)	δ (° ′)
Nov. 11	4 21.7	+59 45
19	4 17.4	61 21
27	4 9.0	62 5
Dec. 5	3 58.6	61 37
13	3 50.1	59 46
21	3 46.7	+56 30

349 DEMBOWSKA (9^M.5)

	α (h m)	δ (° ′)
Nov. 19	5 5.2	+30 28
27	4 57.7	30 44
Dec. 5	4 49.4	30 52
13	4 41.1	30 53
21	4 33.4	30 49
29	4 26.9	+30 40

37 FIDES (9^M.3)

	α (h m)	δ (° ′)
Nov. 11	4 40.0	+26 37
19	4 33.4	26 40
27	4 25.5	26 36
Dec. 5	4 17.3	26 25
13	4 9.6	26 9
21	4 3.4	+25 50

39 LAETITIA (9^M.3)

	α (h m)	δ (° ′)
Nov. 27	5 47.1	+ 7 47
Dec. 5	5 40.5	7 36
13	5 33.2	7 33
21	5 25.9	7 39
29	5 19.0	7 56
Jan. 6	5 13.0	+ 8 20

Hayden Planetarium, American Museum of Natural History,
New York City, October 20, 1937.

OCCULTATION PREDICTIONS

(Taken from the *American Ephemeris*)

OCCULTATIONS VISIBLE IN LONGITUDE +72° 30′, LATITUDE +42° 30′.

Date 1937	Star	Mag.	IMMERSION Greenwich C.T. (h m)	IMMERSION a (m)	IMMERSION b (m)	IMMERSION Angle E from N (°)	EMERSION Greenwich C.T. (h m)	EMERSION a (m)	EMERSION b (m)	EMERSION Angle E from N (°)
Dec. 10	51 Aqr	5.8	1 1.1	−1.2	−0.8	79	2 8.2	−0.5	+0.2	225
15	45 Ari	5.9	4 42.7	−1.3	−0.1	67	5 44.9	−0.9	−1.4	273
15	ρ Ari	5.6	5 16.6	..	..	151	5 39.8	..	..	190
15	13 Tau	5.5	20 33.2	+0.1	+1.1	93	21 23.2	+0.1	+1.7	239
15	14 Tau	6.3	21 9.9	−0.4	+0.5	121	21 48.1	+0.3	+2.4	210
19	162 B.Gem	5.6	12 6.9	+0.1	−1.7	127	12 55.5	+0.1	−1.1	268
20	84 B.Cnc	6.4	12 59.7	−0.1	−1.2	91	13 49.5	+0.3	−1.7	310
21	κ Cnc	5.1	1 18.4	−0.5	−2.6	172	1 39.3	+0.6	+4.2	218
22	14 Sex	6.3	3 23.9	−0.2	+0.4	121	4 24.0	−0.6	+0.9	280
23	p^3 Leo	6.2	6 44.4	−1.2	+0.5	109	7 58.1	−1.2	−0.6	310
28	ι Lib	4.7	10 43.8	..	..	33	11 1.1	..	..	8

OCCULTATIONS VISIBLE IN LONGITUDE +91° 0′, LATITUDE +40° 0′.

Dec.	5	195	B.Sgr	6.3	23	21.0	—1.6	—1.8	107	0	18.9	0.0	+0.6	212
	10	51	Aqr	5.8	0	34.6	—1.6	+0.3	62	1	53.8	—1.2	+0.2	236
	15	45	Ari	5.9	4	12.3	—1.8	+0.4	72	5	29.0	—1.6	—0.4	260
	15	14	Tau	6.3	21	7.0	+0.2	+0.7	107	21	49.4	+0.4	+1.7	226
	19	162	B.Gem	5.6	12	14.4	+0.2	—2.5	154	12	54.6	—0.6	—0.6	245
	20	84	B.Cnc	6.4	12	57.6	—0.5	—1.6	112	13	55.6	—0.1	—1.6	294
	21		ω Leo	5.5	12	9.8	—1.9	—0.3	69	12	55.6	—0.1	—3.0	346
	23		p^3 Leo	6.2	6	28.9	—0.5	—0.1	130	7	34.9	—1.0	+0.7	282
	28		ι Lib	4.7	10	4.9	—0.7	+1.7	83	11	6.2	—0.4	—0.2	317

OCCULTATIONS VISIBLE IN LONGITUDE +120° 0′, LATITUDE +36° 0′.

Dec.	9	51	Aqr	5.8	23	45.4	—1.1	+2.6	24	0	58.6	—2.7	0.0	272
	15		π Ari	5.4	0	3.6	—1.0	+0.6	113	0	45.9	+0.1	+2.5	207
	15	45	Ari	5.9	3	19.5	—1.2	+2.0	53	4	33.0	—2.0	+0.5	265
	15		ρ Ari	5.6	3	45.0	..	..	138	4	14.2	..	..	182
	15	54	Ari	6.5	10	3.0	—0.5	—1.4	104	10	59.3	—0.4	—0.4	246
	16	53	Tau	5.4	13	2.0	—0.5	+0.6	37	13	31.1	+0.9	—2.5	327
	20	29	Cnc	5.9	9	5.3	—2.1	+0.6	90	10	18.2	—1.6	—1.8	317
	20	84	B.Cnc	6.4	12	49.8	—0.3	—3.1	162	13	38.3	—1.9	—0.3	250
	21		ω Leo	5.5	11	18.4	—1.7	—1.4	128	12	37.9	—1.8	—1.3	292

The quantities in the columns *a* and *b* are given for the purpose of making these predictions useful for any place within 200 miles of the point indicated. The procedure is as follows: Subtract the longitude of the point given from the longitude of the place in question; multiply the result, in degrees, taking the signs into account, by the quantity under *a* for the star to be observed; similarly, with the latitude, using *b*; apply the sum of the products, with its proper sign, to the Greenwich C.T., and obtain the predicted Greenwich Civil Time for the phenomenon at the place of observation. To obtain Eastern Standard Time it is necessary to subtract five hours; Central Standard Time, six hours, etc.

Comet Notes

By G. VAN BIESBROECK

This month no further additions have to be reported to the long list of eight discoveries since the beginning of this year. However, none of these comets are at present in reach of ordinary telescopes. Of the four faint ones that can be studied with powerful instruments PERIODIC COMET ENCKE (1937 *h*) is very well placed in November. In the beginning of the month it is near the zenith about 10:00 P.M., moving rapidly westward. By the end of the month the comet will probably have brightened up but it will then be difficult to see in the evening twilight. The following ephemeris established at the Pulkova Observatory by Matkiewicz represents the motion very closely:

1937		α h m s	δ ° ′	——Distance from—— Earth	Sun	Mag.
Oct.	31	23 23 7	+43 53.6	0.338	1.241	9.2
Nov.	1	23 11 33	43 45.3			
	2	22 59 34	43 31.5			
	3	47 13	43 11.7			
	4	34 33	42 45.5	0.307	1.184	8.8
	5	21 39	42 12.4			
	6	8 35	41 32.4			
	7	21 55 26	40 45.0			
	8	42 16	39 50.4	0.285	1.121	8.4
	9	29 10	38 48.5			

1937		α h m s	δ ° ′	Distance from Earth	Distance from Sun	Mag.
Nov.	10	21 16 12	+37 39.7			
	11	3 27	36 24.2			
	12	20 50 58	35 2.6	0.273	1.057	8.0
	13	38 47	33 35.4			
	14	26 58	32 3.2			
	15	15 31	30 26.8			
	16	20 4 29	28 47.0	0.271	0.992	7.7
	17	19 53 50	27 4.4			
	18	43 37	25 19.9			
	19	33 47	23 34.1			
	20	24 22	21 47.7	0.278	0.924	7.5
	21	15 19	20 1.3			
	22	19 6 39	18 15.4			
	23	18 58 20	16 30.6			
	24	50 22	14 47.1	0.295	0.855	7.5
	25	42 43	13 5.4			
	26	35 21	11 25.6			
	27	28 18	9 48.1			
	28	21 30	8 12.8	0.321	0.783	7.2
	29	14 57	6 39.9			
	30	8 39	5 9.6			
Dec.	1	18 2 35	3 41.8			
	2	17 56 44	+ 2 16.4	0.355	0.710	6.9

The brightness seems to be considerably fainter than the computed value. In the first part of October the comet appeared as a well-condensed round coma nearly three magnitudes fainter than the Pulkova prediction.

Comet Whipple (1937 *b*) which has been followed continuously since its discovery on February 7 is fading gradually in the southwestern sky. The most recent observation here made it 14^{M} on October 8. The southward motion will soon put an end to the observations in the northern hemisphere.

The two faint comets Hubble (1937 *g*) and Van Biesbroeck (1935 *d*) can be recorded only with the larger telescopes.

The *Handbook of the British Astronomical Association* gives a search ephemeris for the first return of Periodic Comet Gale (1927 VI) which is expected to reach perihelion next April. The period is about 11 years and after that interval the prediction is naturally uncertain. One can hardly expect the recovery at this early date. However, the chances improve next spring.

Williams Bay, Wisconsin, October 19, 1937.

METEORS AND METEORITES

Meteor Notes from the American Meteor Society

By CHARLES P. OLIVIER, President

Before these notes can appear, the first of the major fall showers will have come and gone, namely the Orionids. But it is hoped that our observers will have paid special attention to them as their importance has often been emphasized. However, November brings the Leonids, December the Geminids; as for the Bielids, there is no reasonable hope for their reappearance. The Leonids are now six years beyond the observed, and four years beyond the presumed maximum. Only

a moderate number can be expected. However, meteoric astronomy is full of the unexpected and, in any case, we wish full records for every year on these meteors. Again we suggest parallax campaigns for the Leonids to our well-organized groups. The Geminids, coming after winter has set in, are rarely observed as they should be. Yet some years they rival or surpass the August Perseids in numbers; always they are good. Their lower angular velocity makes them particularly favorable for photography. Incidentally, more of our members are having some success in this field. We beg of every reader to send us a print, with description on back of each, of every meteor he succeeds in photographing. Only by comparison and study of large numbers can conclusions safely be drawn.

I was observing on 1937 September 29, using an eyepiece with 15-inch field, attached to the 18-inch refractor here, when a telescopic meteor passed. The meteor, lasting not over 0.1 sec, and orange in color, *certainly* crossed the latter half of the field as one of 10 magn., but I have the strongest impression that it was of about 12 magn. for the first part of its course. It passed out of the field so I do not know if it became brighter. This observation makes a note sent in by our member, J. D. Williams, of immediate interest to me. This note will be appended. Williams' observations were made near Tucson, Arizona. An important series of telescopic meteor observations has just come from one of our active Japanese members, Hideo Inouye. These latter were made with fieldglasses (?), aperture 26 mm, power 5, diam. of field 8°.6. He observed the first four days of August, watching the Delta Aquarid radiant. He sends me tracing of the B.D. maps upon which he has plotted the meteors. His success is most surprising.

1937		Began	Ended	Interval	Meteors
Aug.	1	11:55	13:00	65	19
	2	12:20	13:30	70	16
	3	12:00	13:20	80	21
	4	12:00	14:00	120	19
Totals				335	75

The faintest meteor recorded was 9 magn., only 7 were of 5 magn. or brighter. The radiant is not sharp: the meteors seem to radiate, each night, out from two or three centers from 1° to 3° apart. He further sends a table including interval 1935-10-21 to 1936-10-9 with the computed rates for 55 dates, including 4965 minutes of observation and 344 meteors. Inouye is an excellent observer and I hope he will not be drafted for the war in China.

As few of our members see the *Hydrographic Bulletin*, the following is reprinted from that of 1937 September 15, only a few changes in terms being made. I computed these heights last month.

Fireballs of 1937 June 14

As examples of what coöperation on the part of mariners can accomplish, the following two cases are outlined. The original observations all appeared in the *Hydrographic Bulletin*, within the past three months. Six American ships, *Commercial Quaker, Beaconlight, Dorothy, Java Arrow, W. H. Libby,* and *El Valle,* reported the first fireball which appeared at 0751 G.M.T. on June 14. The object was very brilliant, apparently slow in motion, and gave off fragments on its passage. The following data were derived:

Height at appearance	84 km over Long. 82° 53′ W Lat. 25° 28′ N
Height at disappearance	47 km over Long. 81° 24′ W Lat. 27° 20′ N
Length of path	254 km
Velocity	39 km/sec

Radiant ..... Azimuth 36°, Altitude 8° 21′
or ..... Right Ascension 249°, Decl. —41°

It will be seen that the body appeared at a lower altitude than usual: it must have had a considerable mass for a fireball.

The second body, not quite as brilliant, appeared at 084413 G.M.T., and was observed from the three American ships, *W. G. Warden, E. R. Kemp,* and *Argon.* In this case, as the fireball's angular path was very short as seen from two of the ships and headon as seen from the second, the beginning height could not be accurately calculated. All the other data are, however, very accurate. They follow:

Height at disappearance 50 km over Long. 95° 25′ W Lat. 27° 21′ N
Radiant ..... Azimuth 66°, Altitude 8° 19′
or ..... Right Ascension 227°, Decl. —17°

At intervals, special mention is made of the work of some member or group in the A.M.S. In the last two years or more, J. T. Kent of the Department of Mathematics, Texas A.&M., College Station, Texas, has sent in a number of excellent reports, not only of his own and of Mrs. Kent's, but of several friends whom he has been able to interest in meteor work. The Texas group used to be one of our most energetic, but for some years past has done less. It is heartening to see a revival of interest, due to the coming of another observer into the state. Some data follow:

1937	Began	Ended	Interval	F	Meteors	Observer
April 21	15:32	16:32	60	0.8	17	J. T. K.
					14	Mrs. Kent
May 4	14:55	15:55	60	0.6	11	J. T. K.
					7	A. Blumberg
5	15:05	16:16	71	0.6	17	J. T. K.
					12	D. Corley
6	15:15	15:35	30	0.4	7	J. T. K.
7	15:00	16:00	60	0.9	11	J. T. K.
					6	A. Blumberg
Aug. 11	13:20	15:28	128	0.6	83	J. T. K.
					54	C. Mitchell
					40	A. Blumberg
12	13:10	14:45	95	0.6	53	J. T. K.
					41	C. Mitchell

An examination of the maps shows that 10 out of 18 meteors plotted on April 21 were Lyrids. None was faint. The distribution of the paths is such that no good radiant may be derived. In May, the maximum number of Eta Aquarids was seen on May 5; out of 17 meteors plotted 8 were Aquarids, which was a larger percentage than for the other nights. Halley's Comet passed perihelion 27 years ago and is hence within 11 years of aphelion. Yet we find that these Aquarid meteors, moving in orbits approximately the same, are still appearing in fair numbers. This indicates more or less uniform distribution all around the orbit but also proves that we should let no year go by without observing them to get as complete a picture as possible. Observations from other members are at hand for both Lyrids and Aquarids: these will be discussed later. In closing all are again urged to get in as many nights' work as possible for both the Leonids and the Geminids.

Dual Observations of Five Meteors

Dr. Olivier once raised the question as to whether meteors may be detected earlier in flight with the assistance of optical power than with the unaided eye. Apparently five observations bearing on the point were made by R. Knabe, D. F.

Brinegar, and the writer in 1934 and 1935.

(1) Using a sport binocular, 20° field, 1.3×, limiting magnitude 7-7.5, a meteor with extremely great angular velocity was observed. From fainter than 5^M it attained 4^M in the first degree of its observed flight, passing out of the field after 5°. Knabe picked it up 10° later at 4^M, followed it through a long flight during which it reached 2^M and finally ended at 4^M.

The remaining observations were made with a binocular giving a field of 7°.3, 7×, limiting magnitude 10.5-10.7.

(2) A $7^M.5$ meteor passed out of the field after a flight of 2°.5. Knabe observed it at $1^M.5$. The length of the unobserved gap is not given. Four other meteors, 5^M to 8^M, were not seen by Knabe.

(3) A slow moving $4^M.5$ meteor 3°.5 long was observed. Knabe's estimates were the same. He failed to see 12 others, 3^M to 8^M, which were visible in the binocular during the night.

(4) A 7^M meteor was observed for 3°.5 as it left the field. Brinegar saw it at 5^M.

(5) A 7^M meteor increased to 5^M in less than 3°, then leaving the field. Brinegar picked it up 2° later at 3^M and followed it 5°. In the same night that (4) and (5) were observed, 15 additional ones, $4^M.5$ to $8^M.5$, were not detected by Brinegar.

J. D. WILLIAMS.

1937 October 5, Flower Observatory, Upper Darby, Pennsylvania.

Contributions of the Society for Research on Meteorites

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Additional Notes on the Question of Living Bacteria in Stony Meteorites*

By SHARAT K. ROY,
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In the October, 1936, issue of the *C.S.R.M.* in *P. A.*, I have read the criticisms made by Professor Charles B. Lipman (1936) of my publication, "The Question of Living Bacteria in Stony Meteorites" (Roy, 1935). Ordinarily, I should prefer to disregard Professor Lipman's comments, but the subject—the alleged presence of living bacteria of extra-terrestrial origin in stony meteorites—has considerable popular appeal, and I have received a number of inquiries concerning my rejoinder. It is for these reasons that I feel that I should answer Professor Lipman and thus make available to the reading public the facts in the case. I realize that it would be difficult for those interested in the present subject to follow the arguments without having in their minds the contents of the original papers, but,

*The Publications Board and the Editor of the Society wish it understood that they take no part in this controversy (see also the earlier paper by Dr. Lipman, *C.S.R.M., P.A.*, **44**, 442-6, 1936) other than to afford space for the free expression of views on both sides of the question by the investigators concerned.—EDITOR.

since it is not practicable to republish them here, I have, as an alternative, listed them at the end of this paper for contextual reading. Many of Professor Lipman's criticisms are petty quibbles over points that can be quibbled about *ad infinitum*. I have, therefore, chosen the major points and those that can be discussed profitably. It is hoped that the discussion will clarify the situation once and for all.

Professor Lipman objects to my referring to his papers dealing with his "discovery" of living bacteria in ancient rocks and in anthracite coal, on the ground that his work on these subjects and that on stony meteorites are distinct. Where and what is the line of demarcation? Are not his papers, whether relating to rocks, coal, or meteorites, based on his alleged findings of living bacteria in them? In citing his previous papers, however, my object was not to discuss whether the experiments reported therein were similar to or distinct from his work on meteorites but to point out what he has done in the way of searching for bacteria in ancient objects and what corroborations he has received from those who have verified his findings and his ambitous interpretations. His report on the finding of living bacteria in ancient rocks--two from the Pre-Cambrian and one from the Pliocene—appeared in 1928. This finding, which he calls a "startling fact," was not checked by anyone and needed no checking, for after declaring that some of the organisms in the samples were indigenous to the rock, he concludes: "The question of whether they have relatively recently gained access to the interior of the rock or have always been there remains to be determined by further investigations." No reports of these promised investigations, if any, however, have since been published. Three years after the preceding paper, Professor Lipman (1931) reported the finding of living bacteria in anthracite coal and contended that these bacteria had existed in the coal ever since it was formed, some 250 million years ago. Following this announcement, Farrell and Turner (1932) attempted to verify these findings, but failed to do so except in coal that was fractured and thus was exposed to the ingress of bacteria through surface seepage. Professor Lipman charges me with having failed to mention that Farrell and Turner got results similar to his own, but that they chose "deliberately to interpret them [the results] differently." I quote here Farrell and Turner's conclusions as published by Farrell (1933): "Farrell and Turner (*Jour. Bact.*, 1931 [1932?]) attempted to verify Lipman's findings on coal, but were unable to do so except in coal that was fractured and had become infiltrated with bacteria as a result of the seepage of surface and mine water. The microörganisms found in this cracked coal, and in the mine water and mine soil, were apparently identical with those described by Lipman, and were such as are commonly found in air, soil, and water. No bacteria were found in coal that was not fractured or cracked." A glance at the previously quoted passage will prove that I have not misinterpreted the results obtained by Farrell and Turner. True, they got similar results to Lipman's, but under what conditions? Only on coals that were cracked and had become contaminated by seepage of surface and mine water! *No bacteria were found in coal that was not fractured or cracked!*

Now with regard to living bacteria of extra-terrestrial origin in stony meteorites, Professor Lipman vehemently objects to my use of small specimens. He states (1936): "I refer to his [Roy's] choice of very small specimens of meteorites, the largest weighing only 8.65 grams. I have pointed out emphatically and on several occasions that the bacterial populations of rocks and similar materials are never more than very sparse." Bacteria, whether spore-formers or otherwise, are ubiquitous. Their average size is about 2 microns (1 micron or micromilli-

meter = 1/1,000 mm. = about 1/25,000 inch). The total weight of the meteorite specimens I have used is 23.61 grams, having a volume of approximately 15,640 cubic mm.—sufficient to house many hundreds of millions of bacteria. I do not know the bacterial population of rocks, and I cannot cite any authority, but since rocks vary widely in origin, texture, structure, and composition, which are obviously the chief factors that determine the scarcity, abundance, or absence of bacteria, it is safe to state that no general conclusion could be reached, even if extensive studies on the subject were made. Professor Lipman states that the bacterial population of rocks is "never more than very sparse" and attempts to substantiate his statement with the remark, "I have shown that in single specimens of rock like anthracite coal, ten to twenty times the size of the largest meteorite specimen which Roy studied, it often occurs that there are no bacteria." I believe that even Professor Lipman will be willing to admit that coal is not meteorite!

Apart from the untenability of Professor Lipman's analogy between coal and meteorite, he seems to contradict himself when he gives a list of the variety of bacteria he has found in a fragment of the Johnstown, Colorado, meteorite, weighing only 49 grams. The list is as follows (Lipman, 1932, p. 14): "In peptone soil extract, large variable rods were obtained in abundance (*B. megatherium*). Occasional coccus forms visible. In Na_2S peptone soil extract, very short rods or egg-shaped coccus forms, and also large variable rods in small numbers (*B. megatherium*). In addition, the Bristol's Algal Medium was examined and found in this case to contain large rods and large ovoid cells, and some fairly large coccus forms. Some cells there also appeared to be yeast-like or *Torula*-like." To say that the bacterial populations in meteorites "are never more than very sparse" and then to produce such an array of living celestial visitors in 49 grams must appear to everyone a strange form of logic! My reason for choosing small specimens, as I have mentioned in my previous paper, was that they could be handled more easily—an advantage which materially diminishes the chances of their being contaminated during the process of crushing. Furthermore, in spite of the diligent search of Chief Curator Henry W. Nichols and myself, we could not find any larger specimens that were completely crusted. Professor Lipman apparently, does not believe that the specimens I used were completely crusted. This is evidenced from his remark, "When one notes in the photograph which Roy gives of the specimens he used that at least two and perhaps three of the four were not completely crusted." He does not say what "one notes," but I believe he refers to the lighter spots in the photographs. Professor Lipman's suspicion is unwarranted and reveals only his unfamiliarity with meteorites. The lighter spots are thin films of burned material where the outer or heavier black crusts have been either pealed off or never formed. The crust of meteorites is not of equal thickness at every point. This condition is due to the fact that meteorites are the result of oft-repeated fracture, and hence their constantly changing surface is heated to different temperatures at different parts or points.

Not content with his criticism of incrustations of meteorites, Professor Lipman delves into still deeper phases of the subject—the origin, structure, and composition of meteorites. In his attempt to refute my statement that no bacteria were found in pebbles of peridotites and basalt, he states (1936), after omitting the word *composition* which I used, "My experience with densities of peridotites and basalts does not bear out Roy's claim for close resemblance between their structure and that of stony meteorites." It should have occurred to him that the terms *structure* and *composition* are not synonymous and that it is on composition, not structure, that the possibility of bacterial survival is dependent. What close

resemblance there is between the composition of stony meteorites and terrestrial peridotites may be seen in the following passage which I cite from the work of the late Dr. George P. Merrill (1929, pp. 68-9): "These figures [average composition of stony meteorites, peridotites, and rocks of the earth's crust] are of interest when we consider that peridotites, which of all terrestrial rocks most nearly compare with meteorites, are of an igneous nature and of comparative insignificance as components of [the] earth's crust. They occur only as intrusives, that is, they have been forced up in a molten condition from unknown depths and intruded into and between the beds of overlying rocks. Their mineral nature is essentially the same as that of the meteorites, excepting that they frequently have undergone more or less alteration in which water and oxygen have taken a leading part, and contain no unoxidized metal. A striking and almost sensational similarity lies in the fact that they are sometimes diamond-bearing, as are also meteorites, though, so far as now known, only on an almost microscopic scale. The world's supply of diamonds both in South Africa and in the United States comes from terrestrial peridotites."

Professor Lipman then takes up the question of the origin of meteorites and states, in a positive vein: "Moreover, we know that basalts are igneous in origin, but no one knows the immediate origin of stony meteorites, even if we should grant that the matter from which they were formed originally was igneous in origin." Just whom Lipman includes in his *we* I do not know, but those who have studied meteorites and have become recognized authorities seem to know pretty definitely what the origin of meteorites is. As an example, I quote the late Dr. O. C. Farrington (1915, p. 205): "So far as the structure and composition of meteorites are concerned there can be no doubt that meteorites are of igneous origin. All terrestrial analogies indicate that in cosmic furnaces of some sort, fires glowed which gave meteorites the structures which they present to us. As between iron and stone meteorites, some differences of conditions existed which gave them somewhat different structures, since the iron meteorites show well-formed crystallization as if they had been maintained in a uniform condition of temperature, and that sufficient to keep them liquid or viscous for a long time, while the stone meteorites exhibit glass, chondritic structures, and other evidences of hasty crystallization which indicate rapid cooling." I may quote here also a passage from Dr. L. J. Spencer (1933, p. 297) which appeared as a review of Professor Lipman's previous paper (1932): "Organisms could not have originated inside an igneous mass; and if they had been introduced afterwards this could have happened when meteorites were lying in the earth's soil." Incidentally, Dr. Spencer is the leading student of meteoritics today.

Professor Lipman questions even the nature and the number of bacteria I found in my culture media and control plates. He calls my findings a coincidence that "is just too good to be true!" Insinuating remarks such as this, without an explanation as to why it is "just too good to be true," are merely meaningless battles of words, not argument or evidence. I may, however, mention here that my experiments were carried out at the Bacteriological Laboratory of the University of Chicago, supported by Dr. N. Paul Hudson, Dr. Floyd Markham, and, to a lesser extent, Dr. James A. Harrison. Dr. Markham, whose interest and curiosity as to the results were no less than mine, observed every phase of the experiment to its minutest detail and actually coöperated during the process of crushing the meteorite specimens and inoculating the powder into various culture media. When growth appeared (in three of the twelve tubes inoculated, and two control plates), stained smears were made by me, Dr. Markham, and Dr. Harrison, all of

which showed identical results—a coccus and a rod. The organisms were then subjected to an appropriate series of tests and were found to be *Staphylococcus albus* and *Bacillus subtilis*, both of which are met most frequently as contaminants in laboratories. Furthermore, *Staphylococcus* does not form spores, and hence cannot live indefinitely without metabolizing. My interpretation, therefore, that these organisms were contaminants rather than survivors of extra-terrestrial origin, is a safe, conservative, and, above all, a logical one.

The fundamental issue is whether or not extra-terrestrial organisms exist in meteorites. Professor Lipman says that they do. He emphatically announces that "stony meteorites (aërolites) bring down with them from somewhere in space a few surviving bacteria, probably in spore form but not necessarily so, which can in many cases be made to grow on bacteriological media in the laboratory." Now the crucial question is how does he know that the bacteria he speaks of are extra-terrestrial? Why could not they be terrestrial? *Each and every meteorite specimen* that he has used had been in contact with the earth during an unknown interval of time and exposed to multiple agencies of bacterial ingress for periods ranging from eight to sixty-five years, at least. If extra-terrestrial bacteria could gain entrance into meteorites, why could not terrestrial ones? Both are bacteria and both had equal chances. It is obvious, therefore, that his conclusion that he has discovered living visitors from the skies is merely his own personal opinion and is not based on data that anyone searching for truth can or will ever accept.

Lastly, Professor Lipman declares himself to be the pioneer excursionist in the field of life beyond the earth. He asserts (1936): "When I undertook the study of the stony meteorites, there was no evidence, and there is not any now, so far as I am aware, that anybody had preceded me in a similar undertaking. In fact, even today, so far as I am aware, only one other person has worked on the problem and that is Mr. S. K. Roy, who decided to do so only after the paper telling of my findings appeared. In other words, I was and am the pioneer on this subject . . . " What this talk about pioneership has to do with the subject in question is not understandable. To be sure, I should make no attempt to deprive him of the honor of being a pioneer, if he were one. I am afraid, however, that he is not. The pioneer work of which he is a claimant and about which he speaks with such enthusiasm was done well over four decades ago by no less a savant than Louis Pasteur. Pasteur searched for microörganisms in fragments of a stony meteorite, Orgueil (a carbonaceous chondrite), which fell 1864 May 14, 8:00 P.M., at Orgueil, Tarn et Garonne, France, *with negative results!* Reference to Pasteur's investigations will be found in a paper, "Enseignements donnés à la Géologie par les volcans de la Lune," by the distinguished student of meteoritics, Stanislas Meunier (*Scientia*, March, 1925, p. 165). For the convenience of the reader I quote here from Meunier's paper the passage referring to Pasteur's work: "Ces masses, qu'elles soient de pierre, ou de fer, ou même composées de ces deux substances, ou bien charbonneuses, n'ont jamais présenté la moindre trace de corps organisés, et le grand Pasteur qui vint au Muséum me demander des échantillons de la météorite charbonneuse d'Orgueil, que j'eus l'honneur de lui remettre, n'y découvrit aucun germe organique."

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Australites: Are They Glass Meteorites?*

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The range of meteorites has been accepted to include: (*a*) irons, which are metallic, (*b*) stones, which consist mainly of silicates, and (*c*) stony irons, which are intermediate. There is no general agreement that this range should be extended to include, as "glass meteorites," those objects that are called *tektites*. There appears, however, to be a growing volume of opinion tending in that direction. There are at present about eight series of tektites known. The name "tektites," given by Suess, does no more than imply that these objects are "melted." All the known tektite series consist of highly siliceous glasses, Libyan glass being up to 97½% SiO_2. Otherwise, the composition is comparable with, but quite distinct from, that of volcanic obsidian. Tektites are glassy fragments, found in considerable numbers over certain extensive areas in central Europe, Malaya and the neighboring islands, Australia, Tasmania, French Indo-China, the Philippine Islands, the Libyan Desert, and the Ivory Coast of Africa; possibly also in South America. The tektites of each area have their own distinct characteristics. The Tasmanian area is included also in the Australian area; that is to say, in northwestern Tasmania both forms (Darwin glass and australites) may be found. The objects are always wholly glassy, mostly irregular and fragmentary in shape, frequently corroded or abraded, but sometimes quite fresh and of remarkable regularity of form. In weight they vary from one gram up to a few grams, but lumps of Libyan glass occur up to 16 pounds in weight. Usually the region within which any series can be found has been reasonably well defined. Australites occur over an area of 2,000,000 square miles; Libyan glass appears to be limited to an area of 3,000 square miles. The compositions in each case are well known, and are characteristic for each series. Roughly, australites consist of: SiO_2, 70%+; Al_2O_3, 13%+; FeO and Fe_2O_3, 6%+; MgO, 2%+; CaO, 3%+; K_2O and Na_2O, 4%+; with traces of Mn, Ti, Ni, Co; specific gravity, 2.3 to 2.5. Each series has its characteristic color, and may thus be distinguished, except that the three series of southeastern Asia and the adjoining islands are all pitch black. Each series has also a characteristic variety of forms, and with a little experience it

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[The reader is referred also to two other papers on australites by Dr. Fenner, published in the *Trans. Roy. Soc. South Australia*, **58**, 62-79, 4 figs., 6 pls., 1934, and **59**, 125-40, 3 figs., 1935.—EDITOR.]

appears to be a simple matter to distinguish the locality of any tektite from its form and surface markings alone. In highly abraded specimens, chemical and physical differences might need to be determined in order for one to be quite sure of their identity. It has been agreed by Dr. L. J. Spencer that the australites are the most puzzling of all the tektite series. It is because the writer has interested himself particularly in australites, of which he has now examined many thousands of specimens, that Dr. F. C. Leonard has done him the honor of requesting the preparation of this paper, which is therefore devoted mainly to a description of australites. The writer has also visited the heavily forested and largely unpeopled area of northwestern Tasmania, where Darwin glass (or Queenstownite, Suess) occurs, but this particular tektite series is quite distinct in form, color, distribution (and possibly, also, in time) from the australites.

The three authorities who have most interested themselves in the tektite problem are Dr. L. J. Spencer, of London, England, Dr. A. Lacroix, of Paris, France, and Dr. F. E. Suess, of Vienna, Austria. Their recent most informative papers are, respectively, "The Tektite Problem," *C.S.R.M., P. A.*, **44**, 381-3, and Fasc. **2**, 32-4, 1936, also *Min. Mag.* (London), **24**, Mar., 1937; "Les Tectites de l'Indochine," *Archives du Muséum National d'Histoire Naturelle* (Paris), **8**, 1932; and "Zur Beleuchtung des Meteoritenproblems," *Mitteilungen der Geologischen Gesellschaft in Wien*, **25**, 1932. Suess and Lacroix incline to the theory of the meteoritic origin of tektites; Spencer suggests the possibility of their formation by the impact of large meteorites upon siliceous rocks, but agrees that this theory is difficult to apply to australites.

It has generally been accepted that there is no known volcanic rock of the same composition as a tektite, but Dr. F. Fitz Osborne, of McGill University, has directed my attention to a paper by Dr. N. L. Bowen (*Am. Jour. Sci.*, **3**, 1-34, 1922), wherein is described a rock of comparable composition to that group of tektites known as australites. The fact is interesting, but does not appear to have any important bearing upon the problem of the origin of australites. For quite other reasons, the theory of the volcanic origin of tektites has become untenable. Tektites (moldavites) have been known for 150 years. Australites have been known for over 100 years. It is just over a century since Charles Darwin was given a well-formed australite, in Sydney, Australia. which he later described, suggesting a volcanic origin. During succeeding years, these glassy foreign fragments have interested a large number of scientific workers, and there has been a considerable output of literature, with a remarkable variety of theories of terrestrial origin. But, even if it is agreed that tektites, or any one series of tektites, are of meteoritic origin, there still remains a variety of theories as to the mechanics of their formation and distribution. It may be of interest at this point to recall that in 1665 so alert an investigator as Robert Hooke was at one with his scientific contemporaries in discrediting the possibility of heavy foreign bodies (meteorites) falling from the sky. The following list of theories, though not complete, will give some idea of the perplexity of the problem presented by these objects. It refers mainly, but not wholly, to australites, and indicates the reluctance of most workers to accept what is called the "simple and easy" theory of meteoritic origin, and their preference for imagining almost any other conceivable method of production.

Darwin (1844) put forward the theory of the volcanic bomb. From the points of view of form, composition, and distribution, this theory has been abandoned. Clarke (Sydney, 1855) said that they looked as though they had been "cast in a mould." Walcott (Melbourne, 1898) records suggestions that they were "pressed by a saucer-shaped mould." The name "emu stones" preserves a belief

that they were dark-colored pebbles that had been smoothed in the gizzards of emus. There was a European suggestion concerning moldavites that they were relics of a prehistoric glass factory. Twelvetrees (Hobart, 1897) and Verbeek suggested that they were volcanic blebs from the mountains of the moon. Suess (Vienna, 1898) advocated the theory of cosmic (meteoritic) origin. Hildebrand (1905) was more conservative. He asserted that tektites, particularly australites, were artificial products, formed by man, savage or civilized, either by accident or by design. Dunn (Melbourne, 1912) came forward with his volcanic-bubble hypothesis, claiming that the australites originated from bubbles blown from terrestrial lavas. Various other writers have suggested that they were formed by fusion of dust in the earth's atmosphere by lightning. Spencer (*Nature,* 1933) refers to a theory that tektites were colloidal bodies formed by the action of humic acids on the underlying rock, in certain climates. Jensen (Northern Territory, 1915) suggested the origin of australites as limestone concretions. Lacroix and Michel put forward theories that tektites were formed in the earth's atmosphere by the friction and oxidation of meteorites composed mainly of the lighter metals. Spencer (London, 1933) suggested that tektites were formed by the fusion of siliceous rocks at the earth's surface, as a result of the impact of meteorites. The variety of these theories indicates the complexity of the problem of the origin of these small glassy objects.

As has been stated, one of the outstanding characteristics of australites is the regularity and simplicity of the forms taken by them. Of these, the most striking is the "button," a round object symmetrical in form, averaging 1 to 2 grams in weight and looking something like a "pudding in a saucer." The "saucer" portion of the "button" is formed by a flange which projects upward and outward around the equator of the specimen. Because of its nature, this flange tends to break off very readily, and perfect flanged specimens are accordingly relatively rare. The next important form is the "lens," round, and shaped like a biconvex lens. The separating line between the two surfaces in this case is called a "rim." The other regular forms have either flange or rim and are distinguished by their shape in plan, the names indicating their outline: (*a*) "buttons" and "lenses"; (*b*) "ovals"; (*c*) "boats"; (*d*) "canoes"; (*e*) "dumb-bells"; (*f*) "teardrops." Of these forms, "lenses" are by far the most abundant, constituting more than 50% of the specimens, with "buttons," "boats," "ovals," "teardrops," "canoes," and "dumb-bells" in the order named.

The average weight of australites is one gram, the smallest known being $\frac{1}{4}$ of a gram and the largest being 218 grams. They are distributed somewhat irregularly over the whole of Australia and Tasmania and the neighboring islands, south of a line which passes through the northeastern corner of the State of New South Wales and the town of Derby in northwest Western Australia. It is estimated that between one million and ten million australites occur within these limits. It has long been accepted that some part of the form of australites must have been imposed upon them while they were in a liquid or viscid state, spinning forward through the atmosphere.

If one recovers and sorts the material deposited on a tarpaulin immediately behind a railway engine, vast numbers of very minute blebs of glassy material may be obtained, having shapes suggestive of those of australites, *viz.,* "spheres," "ovals," "dumb-bells," "teardrops," *etc.,* but though these things *resemble* australites in form, there is a marked and consistent difference between the actual shapes of australites and those of the tiny blebs formed from the slaggy particles. Microscopic examination of thin sections of australites provides definite evidence of two

distinct and separate periods of melting. This evidence is supported by the macroscopic examination of the surfaces of fresh specimens. The back or upper surface has consistently different features from the front or lower surface. The writer put forward a theory (*Trans. Roy. Soc. South Australia,* **59**, 132, 1935) that the typical "button" (for example) was originally a molten sphere, similar in shape to the little spheres formed in the smoke of a railway engine, and that latterly this glassy sphere, spinning through the atmosphere while still hot, became fused on its forward surface, some of the material flowing back to form the flange and the remainder evaporating or being carried away in the air, thus reducing the mass of the original sphere by nearly fifty percent. It has been objected by Mr. Fletcher Watson, Jr., (*Nature,* 1935) and supported by Dr. L. J. Spencer, that tektites could not have been completely fused during their brief flight through the earth's atmosphere. Accepting this objection as valid, and considering it in conjunction with the definite evidence of two distinct phases of melting, one is forced to the conclusion that there are at least two important chapters in the history of the movement of australites through the atmosphere; *first,* they were formed in some way as spheres and as ellipsoids and in hourglass shapes, possibly in an instant; *second,* while still molten or viscid, they went spinning through the air, re-fusing on their forward surfaces and thus acquiring the characteristic australite shapes. Professor Suess has suggested that the molten glass acquired the original forms at the moment of the blasting of the silica content of a burning light-metal meteorite, the subsequent friction of flight re-melting the front part of each form, as already described. This suggestion constitutes the argument for the meteoritic origin of australites. The whole of the evidence regarding form, composition, and distribution shows that all the australites had their origin at one time. The magnitude of their numbers and the vastness of their distribution, extending alike over rock surfaces of all ages and compositions, invalidate both the volcanic theory of their origin and the theory of meteoritic impact. On the other hand, all the known factors accord with the idea of a single widespread shower of glassy blebs falling upon the earth's surface from some cosmic source.

A Course in Meteoritics at the U. C. L. A.

The Editor wishes to report that he has a class of fifteen "upper-division" (*i.e.* "senior-college") students in a course in meteoritics which is being given for the first time during the fall semester of the academic year 1937-38 in the Department of Astronomy of the University of California at Los Angeles. The new course, known as "Astronomy 118" and named "Meteoritics," is described in the *General Catalogue* of the University for 1937-38 as a course in "The science of meteorites and meteors. Open to upper-division students whose major subject is some physical science, particularly astronomy, geology, or chemistry." The class will meet three times a week throughout the first semester and the course will yield three "units" of credit toward the bachelor's degree in the University. Farrington's *Meteorites* (1915) is being used as the textbook, while Nininger's *Our Stone-Pelted Planet* (1933), the *C.S.R.M.,* and other original papers are serving as collateral reading and source material for the course. It may be of interest to note that of the fifteen students enrolled in the class, five are "majors" in astronomy, nine are "majors" in geology, and one is a "major" in botany! As far as our knowledge extends, this is the second time only that a course in meteoritics has been taught (*cf. C.S.R.M., P.A.,* **43**, 603, and *C.S.R.M.,* Fasc. **1**, 42, 1935).

The Spelling of "Widmanstätten Figures"

In a letter published in *Nature*, **140**, 504-5, September 18, 1937, under the foregoing caption, F. A. Paneth of the Imperial College of Science and Technology, London, England, writes as follows:

"* * * It is certainly no use trying to decide whether 'tt' or 'dt,' 'ä' or 'e' is the more correct spelling of an Austrian name of a hundred years ago; as these differences are not audible in pronunciation, both ways of writing were then considered as equivalent. The 'r' instead of 'n' at the end of the name is a somewhat more serious difference [see paper by the undersigned, "Further Remarks on Meteoritical Terminology," *C.S.R.M., P.A.*, **45**, 49, second, third, and fourth paragraphs, Jan., 1937]. A study of the history of this particular family shows that for decades both forms [of the name, "Widmanstätten" and "Widmanstetter"] occurred; but Cohen, who was already aware of this discrepancy, on the authority of Wurzbach's dictionary, declares in his 'Meteoritenkunde' that the discoverer of the etching figures himself usually wrote 'Widmanstätten,' and therefore this form ought to be chosen. In view of Dr. Spencer's publication [*Min. Mag.*, **23**, 331-3, 1932-34], I asked friends in Vienna and Graz to inquire anew about the form of the name personally used by the scientist. They went rather fully into the question and completely confirmed Wurzbach's and Cohen's statement. Official documents are still preserved which mention Alois von Widmanstätten as the owner of a house in Graz, as the inventor of a balance, *etc.*

"Keepers of meteorite collections may be glad to learn that there is, therefore, no reason to alter the hundreds of labels bearing the name Widmanstätten" —to which we may add, of course not, unless, perchance, still further investigation should disclose that "Widmanstetter" is really the authentic form and so reverse Paneth's conclusion! Meanwhile, one may "pay his money and take his choice" in the matter of the spelling of this proper name and the technical term compounded of it!

FREDERICK C. LEONARD.

VARIABLE STARS

Variable Star Notes from the American Association of Variable Star Observers

By LEON CAMPBELL, Recorder

The A.A.V.S.O. Meeting: The twenty-sixth annual meeting of the A.A.V.S.O. was held at Cambridge, beginning with a joint meeting of the Bond Astronomical Club and the Association on Friday evening, October 15, and ending with an excursion to the Oak Ridge station of the Harvard Observatory on Sunday, October 17. At the Friday evening session Dr. Charles H. Smiley of the Ladd Observatory of Brown University was the guest speaker, and his travelogue describing his trip to Peru to observe, with a Schmidt camera, the June 8 eclipse of this year, was not only highly entertaining but distinctly instructive. His three novel photographs of the eclipse—apparently the first attempt with a Schmidt camera—certainly opens up a new field of research for the 1940 solar eclipse expeditions.

At the meeting of the Council held on Friday afternoon, the fourth Merit Award of the Association was voted to Eugene H. Jones of Goffstown, New

Hampshire. Mr. Jones has contributed over thirty thousand observations during his fifteen years of activity in the Association and for the past three years has been at the head of the list of contributors.

Dr. Dirk Brouwer of the Yale Observatory resigned as chairman of the occultation committee in the Association, and Miss Anne S. Young, Professor Emeritus of Astronomy at Mount Holyoke College, has assumed that important position.

The regular business meeting of the Association was held on Saturday, with reports of officers and committees, election of council members and officers, and the presentation of papers.

An outstanding feature of the gathering was the preponderance of newer and younger members of the Association. A large delegation was present from Milwaukee, Wisconsin, and a major portion of the papers presented were by these newer members of the Association.

Dr. Brouwer reported on the progress of the work of the occultation committee, announcing the completion of the reduction of more than three hundred occultations observed in the year 1935. Professor E. W. Brown followed with a tribute to the value of the work of the committee, and especially to the untiring efforts of the retiring chairman. Mr. L. E. Armfield reported on the work of the nova search committee, one of the most important committees of the A.A.V.S.O. Besides the assignment of most of the northern fields to numerous observers, many southern fields have been allotted to observers in the southern hemisphere. It is safe to assume that no new stars brighter than the fourth magnitude have appeared in the fields being watched by the observers in this work.

The sixth annual report of the Recorder cited the activities of the Association which come under his care. The Charles Y. McAteer Library has been greatly increased and its value immeasurably enhanced by the addition of nearly six hundred volumes from the library of the late J. Ernest G. Yalden. While a third of these volumes pertain to mathematics—some of them exceedingly rare and valuable—there are many up-to-date books dealing with astronomy. A supplementary catalogue of these recently-added volumes is to be issued soon. There was a slightly increased use of the slide collection over that of recent years.

The telescope loan department continues to function to the mutual advantage of observers and the Association. The 4-inch Morris telescope, bequeathed to the Association last spring, was used successfully by an observer at Bar Harbor, Maine, during the summer. Telescopes loaned to observers at Goffstown, New Hampshire, Milwaukee, Wisconsin, Delphos, Ohio, New York City, Tucson, Arizona, Bologna, Italy, and Bagchar, India, not to mention numerous others, continue to prove their value in the efforts of the Association to increase variable star observing.

Of the publications of the Association, five numbers of Variable Comments have appeared: "The Fifth Annual Report of the Pickering Memorial Astronomer"; "The Twenty-Fifth Annual Meeting of the A.A.V.S.O., October, 1936"; "The History of the American Association of Variable Star Observers"; "The 1937 Spring Meeting"; and "A Tribute to the Memory of J. Ernest G. Yalden."

Three additional numbers of *Harvard Annals* 104, containing the variable star observations contributed to the Association, have been issued, and a fourth is in press. A total of 53,358 observations were contributed during the year. Messrs. Jones and Hartmann again head the list with 4275 and 3134 observations to their credit, respectively, followed by Loreta of Bologna, Italy, Houston of Milwaukee, Wisconsin, and Peltier of Delphos, Ohio. Observers to the number of 166 took part in the observing program, and in the twenty-six years which

have elapsed since the Association began its work in 1911, more than six hundred thousand observations have been contributed by more than six hundred different observers. As has been previously noted, some of these observers have been continuously active during the whole span of years.

Newly-elected members of the council for two years are Mrs. Phoebe W. Haas of Villa Nova, Pennsylvania, and Mr. David W. Rosebrugh of Poughkeepsie, New York. Messrs. L. E. Armfield and C. P. Olivier were re-elected for terms of two years to the council. The newly-formed council elected the following officers for the new year:

President, Charles W. Elmer
First Vice-president, L. E. Armfield
Second Vice-president, Helen S. Hogg
Secretary, David W. Rosebrugh
Treasurer, Percy W. Witherell
Recorder, Leon Campbell.

The retiring president, Dr. Harlow Shapley, remains as a member of the council for four years.

Papers presented included:

Remarks on Zeta Aurigae, 1937, by Alice H. Farnsworth.
Notes Concerning Sunspots, by George P. Kirkpatrick.
Observing the Asteroid Vesta, by D. W. Rosebrugh.
Zwicky's Super Nova in NGC 1003, by Dorrit Hoffleit and L. E. Cunningham.
Photographic Observations of Red Variables, by J. L. Woods and P. S. Watson.
Richest Field Telescopes, by R. A. Seely.
The Red Variable U Cygni, by L. Campbell.
Yalden's Pier-model Sundial, by J. A. Ingham.
The Construction of the Milwaukee Astronomical Society Observatory, by E. A. Halbach.

The guest speaker at the Saturday evening banquet was Dr. Eric Lindsay, recently appointed director of the Armagh Observatory, Ireland, who gave us a vivid description of life and conditions at the Boyden Station of the Harvard Observatory at Bloemfontein, South Africa. Mr. W. B. Stearns recounted his experiences in connection with his duties as official delegate of the Association to the fiftieth anniversary of the founding of the Société Astronomique de France. Dr. Shapley again presented his "Highlights of Astronomy," for 1937, interspersed between his introductions of the various speakers.

On Sunday, the 17th, twenty or more members journeyed to Oak Ridge to be instructed in the science of seismology by Dr. L. don Leet, and to inspect the astronomical equipment of that station, under the guidance of Dr. G. Z. Mimitroff.

Super Nova in NGC 1003: The super nova recently discovered by Dr. Zwicky, at Palomar, in the nebula NGC 1003 has been carefully studied, visually as well as photographically, by Miss Hoffleit and Mr. Cunningham of the Harvard Observatory staff. The maximum magnitude attained appears to be about 12.5, or slightly brighter than the star 30″ distant. A comparison of the photographic and visual light curves indicates a positive color index of $0^{M}.6$. While the diminution in brightness of the nova was at first somewhat slow, it later decreased more rapidly, and was fainter than photographic magnitude 15 on October 11. Nothing is known regarding the rapidity of rise to maximum.

The published statement by Morgenrath of Sonnenberg, that the nova appeared as a variable object from July, 1936, to September, 1937, does not appear to be confirmed on Harvard plates showing stars as faint as the fifteenth magni-

tude. The object observed by him as variable may have been the nucleus of the nebula. Such a confusion would have been possible if small scale plates were used, as is evident from an examination of the Harvard AI plates (1200″ to the mm.).

The present magnitude of the nebula is about 13.6. At maximum the nova was at least as bright as magnitude 13.0. The brightness of this one star was therefore twice as great as the total brightness of the galaxy that includes it.

Observations for September: Observations were received from 77 observers during the month of September, as shown by the following list:

Observer	Vars.	Observations	Observer	Vars.	Observations
Ancarani	8	28	Kitchens	12	26
Atchison	1	1	Knott	2	2
Baldwin	110	253	de Kock	43	148
Benini	2	12	Kotsakis	11	88
Blunck	54	68	Kozawa	19	78
Brown, S. C.	13	13	LaFon	40	50
Buckstaff	20	109	Lizarraga	4	4
Callum	56	130	Loreta	111	280
Cameron	13	17	Meek	8	13
Campbell	4	4	Millard	28	49
Carpenter	175	210	Monnig	7	7
Chandra	72	142	Murphy	11	18
Cousins	16	160	McLeod	30	62
Dafter	11	23	McNabb	2	5
Dalton	4	13	Palo	4	4
Diamantopoulos	6	73	Peck	18	42
Diedrich	2	6	Peltier	197	273
Ellis	74	151	Plakidis	9	47
Elmer	2	2	Pursell	2	2
Ensor	65	149	Richter	6	6
Escalante	26	28	Rosebrugh	8	26
Evans	15	26	deRoy	14	23
Fairbanks	11	24	Russell	26	54
Fernald	8	27	Ryder	6	6
Franklin	42	54	Seely	6	8
Gregory	149	157	Sill	38	42
Hamilton	25	68	Smith, F. P.	28	31
Hartmann	140	248	Smith, F. W.	3	4
Herbig	90	260	Smith, J. R.	26	26
Hiett	21	52	Smith, L.	24	26
Hoffleit	1	3	Strelitzer	16	26
Holmes	4	4	Thorne	5	5
Holt	53	77	Treadwell	17	61
Houghton	78	234	Watson	20	36
Houston	80	345	Webb	57	64
Howarth	18	20	Woods	20	38
Jones, E. H.	124	152	Yamasaki	8	8
Jones, M.	2	26			
Kanda	3	23	77		5314
Kirkpatrick	21	84			

The following observers have contributed for the first time to these reports: A. T. Diamantopoulos, Athens, Greece; Marjorie Jones, Hines, Oregon; A. U. Palo, Los Angeles, California; A. L. Pursell, Tulare, California; and K. Richter, Bridgewater, Massachusetts.

Edwin F. Sawyer: With the death of Edwin F. Sawyer at Newton, Massachusetts, on October 14, variable star astronomy has suffered the loss of one of America's pioneers in variable star observing. For more than fifty years Mr. Saw-

yer maintained a deep interest in variable stars and during the 80's and 90's, in collaboration with Chandler and Yendell, did much to add to our knowledge of these stars during these years. Mr. Sawyer worked in the days when it was necessary to select and estimate his own sequences, make his own charts, and overcome many of the difficulties with which variable star observers of today do not have to contend. Mr. Sawyer died at the age of eighty-eight, having served for sixty-four years as an official of one of the prominent banks in Boston, Massachusetts. In recent years Mr. Sawyer attempted to collate and reduce much of his work of the earlier years. It is to be hoped that this work is in such condition that the results may be made available to variable star astronomers.

October 20, 1937.

Notes from Amateurs

Quick Method for Conversion of Standard Time into Sidereal Time

The amateur astronomer, who does anything worth while, will appreciate the need of sidereal time. Anyone who has a short wave radio set can pick up United States Naval Observatory time signals from Arlington and, if he has a clock running on sidereal time, can have an easy way to convert standard into sidereal time and thus correct his sidereal clock from time to time.

The following table was constructed for use in my own observatory, at longitude 105° 5′ W, which is in the Mountain Standard Time belt, but the reader can construct a table like this for any longitude.

CONVERSION OF STANDARD TIME INTO SIDEREAL TIME
(for Longitude 105° 5′ W. In Time $7^h\ 0^m\ 20^s$)

M.S.T.	Local Time	Gain in Sidereal Time $7^h\ 0^m\ 20^s$ from Greenwich	Gain in Sidereal Time from 0^h	Constant to be added to R.A. of Mean Sun plus 12^h for any date to obtain the corresponding sidereal time
A.M.	h m s	m s	m s	h m s
1	0 59 40	1 9.050	0 9.802	1 0 58.852
2	1 59 40	1 9.050	0 19.659	2 1 8.709
3	2 59 40	1 9.050	0 29.515	3 1 18.565
4	3 59 40	1 9.050	0 39.372	4 1 28.422
5	4 59 40	1 9.050	0 49.228	5 1 38.278
6	5 59 40	1 9.050	0 59.085	6 1 48.135
7	6 59 40	1 9.050	1 8.941	7 1 57.991
8	7 59 40	1 9.050	1 18.798	8 2 7.848
9	8 59 40	1 9.050	1 28.654	9 2 17.704
10	9 59 40	1 9.050	1 38.510	10 2 27.560
11	10 59 40	1 9.050	1 48.367	11 2 37.417
12	11 59 40	1 9.050	1 58.223	12 2 47.273
P.M.				
1	12 59 40	1 9.050	2 8.080	13 2 57.130
2	13 59 40	1 9.050	2 17.936	14 3 6.986
3	14 59 40	1 9.050	2 27.793	15 3 16.843
4	15 59 40	1 9.050	2 37.649	16 3 26.699
5	16 59 40	1 9.050	2 47.506	17 3 36.556
6	17 59 40	1 9.050	2 57.362	18 3 46.412
7	18 59 40	1 9.050	3 7.219	19 3 56.269
8	19 59 40	1 9.050	3 17.075	20 4 6.125
9	20 59 40	1 9.050	3 26.932	21 4 15.982
10	21 59 40	1 9.050	3 36.788	22 4 25.838
11	22 59 40	1 9.050	3 46.645	23 4 35.695
12	23 59 40	1 9.050	3 56.501	24 4 45.551

Explanation: The second column is the local time corresponding to the standard time of the first column. The third column indicates the gain of sidereal time over civil time while the earth is turning on its axis from the meridian of Greenwich to the local meridian. The fourth column indicates the gain in sidereal time from midnight for each hour of the day (third and fourth columns found from Table III of the *American Ephemeris*). The fifth column is the sum of columns two, three, and four.

Example: Required the local true sidereal time corresponding to 8:00 P.M., on August 12, 1937.

	h	m	s
From the above table for 8:00 P.M.	20	4	6.125
From the *Ephemeris*, R.A. of mean sun plus 12 hours, for August 12, 1937 (p. 10)	21	20	6.187
Required local true sidereal time (deducting 24 hours because the sum is too large)	17	24	12.312

This is a shortcut of the method given on page 826, paragraph 3, of the *American Ephemeris* for 1937. It does not take account of nutation, whose maximum value is scarcely more than a second, for the purpose of obtaining local uniform sidereal time. For the amateur this refinement is unnecessary.

The final column of the above table consists of constants for each hour of the day to which one can add the right ascension of the mean sun, plus 12 hours, as given in the *Ephemeris* for any certain date, and he has the local true sidereal time. In other words, he can add two quantities together, listen for the radio signal indicating the even hour of standard time, know the exact sidereal time at the instant and set his clock accordingly.

In preparing a table for his own longitude the reader should set up in the first column the standard time for his own time belt, in the second column the local time corresponding thereto and in the third column he should show the gain in sidereal time over civil time from the meridian of Greenwich to his own meridian (Table III of the *Ephemeris*), counting the difference in longitudes in time instead of in degrees. The fourth column will be the same for all longitudes.

Berthoud, Colorado. JOHN BUNYAN.

Amateur Astronomical Society of New Haven

The New Haven Amateur Astronomical Society held its first meeting of the season on September 18 in the Yale Astronomical Building.

The telescope-making group reported much activity during the summer and real progress was made. One six-inch reflector is now completed and mounted, and is affording much pleasure, new information and interest to its owner and his many friends. One of our members has constructed a lens-grinding machine which produces excellent results and in a much shorter time than could be accomplished by hand. Mr. Becroft, the owner and maker, gave a demonstration of its work at one of our telescope group meetings, and in three hours ground a 6-inch mirror to a depth of .030.

Reports were made of a few of the many summer activities including a number of meteor observing gatherings which were held in conjunction with a group at Vassar College. A trip was made by ten of our members to Springfield, Vermont, to attend the Annual Conference of Amateur Telescope Makers, and a delegation of nine attended the Third Annual Meeting of the Norwalk Astronomical Society. These last two meetings were very profitable to all who attended, as

much information was obtained and many new and valued acquaintances were made.

Mr. Milton Corbett addressed the society on the subject, "The Earth and Its Motions," and by means of quite elaborate charts projected upon a screen, he explained the many complicated and intricate principles and laws of motion to account for the earth's many and varied gyrations. Starting with Eratosthenes' measurement of the earth's circumference and Hipparchus' discovery of the precession of the equinox, he traced the development of the two subjects up to the time of Newton who deduced by pure theory the shape of the earth and the result of that shape on the motions of the earth in space. Eratosthenes hearing of a deep well in Syene into which the sun, at noon on the day of the summer solstice, shone straight down to the bottom, measured the angle of the sun at Alexandria and found it to be seven degrees, and, knowing the distance to Syene, the two places being on the same meridian, he readily computed the arc and then the circumference of the earth which was 252,000 stadia, and as one stadium was 516.73 feet he found the circumference to be 24,662 miles corresponding to a polar diameter of 7,850 miles, or only fifty miles less than the true polar diameter.

Mr. Corbett explained by means of charts, Hipparchus' discovery of the precession of the equinox and clearly showed how much the intersection of the celestial equator and the sun's path had advanced from the year 300 B.C. to 150 B.C. He also explained Newton's deductions of the oblateness of the earth and the consequent phenomenon of precession by both diagram and gyroscope model. His talk was much appreciated by all present.

F. R. BURNHAM, *Secretary.*

The Cleveland Astronomical Society

The Cleveland Astronomical Society held its first meeting of the year 1937-38 at the Warner and Swasey Observatory, Friday evening, September 24. After a general business meeting Miss Helen Focke, a member of the society and of the staff of the Cleveland Public Library, gave a résumé of the Library's collection of books, periodicals, and charts which might be of interest to members of the society.

Dr. H. H. Nininger, of the Museum of Natural History, Denver, Colorado, visited the meeting and described some of his experiences in the search for meteorites. His extemporaneous discussion was greatly enjoyed by those present.

JEANNETTE MCCUSKEY, *Secretary.*

The T-term in Formulas of Elements and Constants

In the formulas of sun, moon, and planetary elements, precessional constants, etc., the symbol T is generally taken to express time measured in Julian centuries of 36525 days. Sometimes t may be used in a formula instead of T, but as t in such a case is supposed to be measured in Julian years of 365.25 days, the change from t to T involves a movement of the decimal point only, in the terms of the formula.

When the terms of the formula are in seconds of arc, and the result of the numerical solution is wanted in degrees, minutes of arc, and seconds of arc, calculations may be somewhat simplified by the use of the three auxiliary tables given herewith. In like manner the tables facilitate the operations when a solution is wanted in hours, minutes, and seconds, from a formula with the terms given in

seconds of time. The tables are:

I Decimal point 4 places to left.	13149
2	26298
3	39447
4	52596
5	65745
6	78894
7	92043
8	105192
9	118341

II Decimal point 2 places to right.	21915
2	43830
3	65745
4	87660
5	109575
6	131490
7	153405
8	175320
9	197235

III Decimal point 2 places to right.	36525
2	73050
3	109575
4	146100
5	182625
6	219150
7	255675
8	292200
9	328725

As will be seen, the units of these tables are 13149, 21915, and 36525, respectively, and the columns show multiples of these units.

The unit of Table I is arrived at by removing the last four ciphers from the product 36525×3600, or the number of days in a Julian century multiplied by the number of seconds in one degree, or one hour. To obtain the unit of Table II, the last two ciphers have been discarded in the product 36525×60, the multiplier being here the number of seconds in one minute. In Table III the unit is equal to the number of days in the Julian century.

The practical use of the tables is best illustrated by a couple of examples. We are for instance going to compute the mean longitude of the earth's perihelion for 1937 January 1.0 U.T. In this first example the terms of our formula are supposed to be expressed in seconds of arc, and in the solution we want as much accuracy as the formula allows.

According to Newcomb our formula should read, for the epoch 1900 January 0.0 G.M.T. = J.D. 2415020.0.

$$\pi = 101^\circ\ 13'\ 15''.0 + 6189''.03\ T + 1''.63\ T^2 + 0''.012\ T^3$$

The solution will be as follows:

1937 Jan. 1.0 = J.D. 2428 534.5
1900 Jan. 0.0 = J.D. 2415 020.0

13 514.5 days

$$6189''.03 \times 13514.5 = 83\ 641\ 645''.935$$

In this product we should, according to the remark at top of Table I, move the decimal point 4 places to the left, in order to obtain whole degrees by dividing with the unit of that table. But if we do so the dividend will be smaller than the divisor, indicating that the solution holds no whole degrees. Or

$$8364.1645935/13149 = 0^\circ$$

So we move the decimal point 2 places to the right, as remarked at top of Table II, and divide by the unit of that table, in order to obtain the whole minutes of arc which the solution contains. We then have,

$$836416.45935/21915 = 38'$$

and a remainder of 3646.45935 in which we move the decimal point according to the instructions at top of Table III, continuing the division by the unit of that table. This gives,

$$364645.935/36525 = 9''.983$$

As the terms in the formula to be multiplied by T^2 and T^3 are small, we solve

them by logarithms, and have,

Epoch 1900 Jan. 0.0 G.M.T.	101°	13′	15″.0
6189″.03 T	0	38	9.98
1.63 T^2		0	0.22
0.012T^2			0.00
Longitude of earth's perihelion 1937 Jan. 1.0 U.T.	101°	51′	25″.2

For our second example we will take the formula of the right ascension of the mean sun, as given by Newcomb, computing from it the sidereal time for 1937 January 1.0 U.T. We have for the right ascension of the mean sun, affected by aberration,

$$18^h\,38^m\,45^s.836 + 8\,640\,184^s.542\ T + 0^s.0929\ T^2$$

the epoch of the formula being the same as in our first example, 1900 January 0.0 G.M.T. Hence the solution will be as follows:

$$8\,640\,184^s.542 \times 13514.5 = 116\,767\,773\,992^s.859$$
$$11\,676\,777.3992859/13149 = 888^h$$
$$46\,539.92859/21915 = 2^m$$
$$270\,992.859/36525 = 7^s.419$$

As in our first example we use logarithms for the small term to be multiplied by T^2, and have:

	h	m	s
Epoch 1900 Jan. 0.0 G.M.T.	18	38	45.836
8 640 184^s.542 T	888	02	07.419
0.0929 T^2			0.013
Sum	906	40	53.268
$24^h \times 37$	888		
1937 Jan. 1.0 U.T. R.A. of mean sun	18	40	53.268
Hour angle of mean sun at 0^h	12		
1937 Jan. 1.0 U.T. Uniform Sidereal Time	6	40	53.268
Nutation in R.A.			1.092
1937 Jan. 1.0 U.T. True Sidereal Time	6	40	54.360

If one has to do much computation like this, one should have a table of multiples for the T-term of the formula. For this term in the formula of the right ascension of the mean sun, affected by aberration, as given by Newcomb, such a table is here presented:

	8 640 184.542
2	17 280 369.084
3	25 920 553.626
4	34 560 738.168
5	43 200 922.710
6	51 841 107.252
7	60 481 291.794
8	69 121 476.336
9	77 761 660.878

HANS A. ERIKSEN.

Kreftings gt. 5, Hønefoss, Norway, November, 1936.

General Notes

Georges M. Horsch has recently been honored by the government of Greece in his appointment as Director of the National Observatory at Athens.

Dr. Peter van de Kamp, director of the Sproul Observatory of Swarthmore College, Swarthmore, Pennsylvania, delivered an address at the Franklin Institute on Friday evening, October 15, under the auspices of the Rittenhouse Astronomical Society. Dr. van de Kamp's subject was: "Our Stellar Neighbors." Following the address a reception was tendered to Dr. van de Kamp by the President and Board of Governors of the Society.

Auroral Display Observed at the McDonald Observatory

An interesting auroral display was observed at the McDonald Observatory on Sunday night, October 3, and since it was seen from a point at rather low latitude, 30° 40′, a brief record of it may be of interest. The display was noticed by Jessie Rudnick, shortly after the end of twilight as a reddish illumination covering the northern horizon and extending to an altitude of about 10°. The illumination at first was quite bright and distinctly red but soon the color faded leaving the usual low auroral arch, centered over magnetic north. Later, patches of light were observed within the arch which varied and changed color. Two streamers were seen to extend from about the north point across the northwestern sky for 70° to 80°, one making an angle of about 10° with the horizon and the other an angle of about 30°. For about an hour they were fairly constant and then disappeared. From 11:00 to 11:30 P.M. C.S.T., short streamers were seen to the north varying in position and brightness, and they were mostly red in color. Some of them extended to the altitude of the pole.

C. T. Elvey.

McDonald Observatory, Fort Davis, Texas.

New American Planetarium for Springfield, Massachusetts

The first American designed and built planetarium will open to the public at the Springfield, Massachusetts, Museum of Natural History on November 2. At the present, the planetariums in this country may be counted on the fingers of one hand and Springfield's makes the fifth and certainly the most unique in many respects.

When the Springfield museum opened its doors three years ago following extensive enlargements, a second floor hemispherical gallery 40 feet in basal diameter and 24 feet central height and without windows or skylight was dubbed the department of mystery.

The idea of a planetarium as a nucleus for a long-desired department of astronomy originated with Frank D. Korkosz, technician of the museum. "Why not utilize the dome-ceiling as the 'sky' for such a planetarium?" reasoned Mr. Korkosz. This idea, at first received with skepticism, found more concrete expression in plans which received the whole-hearted approval of the museum's director, Mrs. Grace P. Johnson, as well as the museum's board of trustees.

While the New York (Hayden), Chicago (Adler), Philadelphia (Fels), and Los Angeles (Griffith) installations employ apparatus of foreign manufacture costing about $150,000 each, Springfield's projector has cost less than $12,000 and is wholly American-designed and American-made. This vastly lower cost is bound

to have a far-reaching effect, for it clearly shows the possibility of such apparatus for educational purposes in museums, colleges, public schools, and even parks in smaller cities.

Springfield's planetarium gallery with its diameter of 40 feet compared with New York's 75 foot diameter, seats approximately 150 persons comfortably, and this capacity after the first rush of attendance will doubtless be entirely adequate for a community the size of Springfield (population of greater Springfield, 250,000). The planetarium projector is comparatively small, compact, simple to operate and flashes the stars on the dome with great fidelity. All in all, the same results can be achieved with the Springfield instrument as with those more elaborate installations in other cities.

The Big Ball

The aluminum ball of the projector which is set in its "cradle" in the center of the planetarium weighs only 2,500 pounds. The parts are of cast iron, steel and sheet aluminum, hammered out and welded by hand. There are also cast bronze parts. Local shops turned out and assembled these parts. The optical lenses, made in Brooklyn, New York, were carefully selected, tested and assembled by Mr. Korkosz. The height of the projector is 7½ feet, and it is 5 feet in diameter.

The big ball is capable of rotation in its cradle on a north to south axis and reverse, as well as an east-west axis and reverse. The principle of this or of any projector is somewhat on the idea of the old-fashioned magic lantern, only very much more complicated, of course. Light is projected from a 500 watt flood lamp inside the ball through perforated lantern slides or star charts by means of lenses distributed over the ball and is thrown on the dome ceiling. By this composite blending together of sky pictures on the dome a complete night sky with all the stars is to be had.

The operator who stands at the control dials has as complete a mastery over the planetarium as a ship's captain on his bridge or a stage director behind his scenes. By a flick of his finger on a knob the exit and entrance signs appear and disappear, the lights are dimmed or stepped up, the musical prelude that accompanies the demonstration started, and the projector made to reveal its many dozens of tricks which will produce constellations and eventually comets, eclipses, aurora-borealis, milky way, and other celestial phenomena.

By the rotation of the projector on its axis one sees the star-spangled heavens in their 24-hour motion about the North Star. There is another axis to produce precessional motion. The altitudinal motion is produced by the action of the cradle and pictures what are circumpolar constellations to a person at the North Pole or to one at the South Pole, to one at the equator or at any intermediate points. A mechanism to be incorporated in the design will illustrate planetary motion.

To point out a single star or a group of stars, the operator has no big stick with a light attached as one would think, but he manipulates a device which throws a movable comet-like indication on the dome, the head of the comet being analogous to the customary arrowhead.

An individual projector in the big ball contains two condensers and one projector lens. The observer sitting in the Springfield planetarium, were he successful in counting the number of stars projected on the dome, would total up 7,150! The planetarium is capable of producing sky areas as seen from any place on earth at any time—that is 25,000 years forward and 25,000 years back, a span of 50,000 years.

Greatly enhancing the realism of the Springfield planetarium will be the

twinkling effect of stars and the natural colors of certain stars such as the red of Antares. This achievement is entirely original with Mr. Korkosz and seems not to have been accomplished elsewhere.

THE "LOCAL TOUCH"

The local Springfield citizen entering the planetarium should feel perfectly at home, for a skyline of Springfield in silhouette and murals as actually seen from the museum roof and pieced together from panoramic photographs which include all compass points forms the background of the circular room. Stanley Korkosz, younger brother of Frank, and who is also on the museum staff and is noted for his mechanical versatility, "boxed" the camera around all points of the compass and reconstructed the horizons on the planetarium backdrop or wall.

The illusion of sunset is created with a reddish glow in the west, and above it the late afternoon sky of deep blue. As the sun apparently sinks lower beyond the horizon and the shades of night begin to fall, subdued music is heard. Then the first magnitude stars begin to appear. Increasing darkness intensifies the brightness of these and makes others visible until finally the deep and silent night produces a vast, brilliant starlit sky and all consciousness and limits of the dome are obliterated.

Not least about Springfield's planetarium are the provisions for the individual spectator. The air is conditioned and kept always fresh in the same manner as in the most modern theatre or railway coach.

Acoustical difficulties which had seemed a problem at first, have been corrected by the expedient of adding simple slip-covers over original metal covers to all chairs. Thus is obviated the necessity of sound-treating the walls, at first thought unavoidable. All the chair slip-covers for Springfield's planetarium were made as a special sewing project by the girls' division of the Springfield Trade School.

Sound equipment for music and voice includes five speakers concealed behind the dome. Included is an 18-inch speaker for notes in the bass register and "tweeters" for the high notes. Both sets are separately controlled.

The better part of three years has been given to the designing and construction of the planetarium by Frank Korkosz. Designing an original planetarium without consultants or any patterns to work with, and which simply must prove satisfactory when finished was a job tackled by young Mr. Korkosz with complete confidence resulting from other achievements such as the designing and installation of the museum's aquarium with its filtered, balanced, and circulatory system, which aquarium stands unique among museum-installed aquariums in the country. Also to his credit is the faithfully reproduced Indian Workshop group in the museum's Hall of the American Indian.

Book Reviews

Man in a Chemical World, by A. Cressy Morrison. (Charles Scribner's Sons, 285 pp. Illustrated. Price $3.00.)

This is a presentation for the layman of the dependence of man on the rapidly developing chemical industry. Its great importance is clearly emphasized in the eleven chapters which are entitled: 1. Nature Points the Way, 2. Chemistry in Overalls, 3. Keeping Well, 4. Feeding Millions, 5. Wheels and Wings, 6. From Papyrus to Television, 7. All the Comforts of Home, 8. Serving Industry, 9. Security, 10. The More Abundant Life, 11. The Crystal Reveals. It gives a "review of the contributions of chemical industry to every human being." As Mr. Hixson

in the Foreword says, "Chemistry is the key to modern material civilization and the hope of the future," for man is "able to enjoy the blessings of chemical science in the form of high standards of living." These industries are "the mighty pillars of support for the nation's whole industrial mechanism and means of defense, supplying products that are basic for practically every other industry."

The author's survey of chemical industry is interestingly interwoven and simply told so that it should be readily understood by those who wish to know something about the applications of chemistry and particularly enjoyed by those technically versed in chemistry and chemical industry. A. T. LINCOLN.

The Distribution of the Stars in Space, by Bart J. Bok (The University of Chicago Press 1937. $2.50.)

Dr. Bok's volume of 124 pages provides an illuminating summary of the problems whose solution will give a clear conception of the structure of the stellar world. We feel that we are here close to the frontiers of recent conquests. We learn to understand the purpose of the investigations that are under way and what part these play in the general problem. The whole outlook is towards the future with only very condensed reference to former attempts or to previous literature.

The book is divided into three main parts: under the first the methods of interpreting the data are discussed, how to infer the space densities from the apparent ones, how to get a clue to the distances of dark nebulae and to their absorption. The second part deals with the observational data such as star counts, distribution of spectra and dark nebulae. The interpretation of the galactic structure is the subject of the third section; the author is not proposing new hypotheses concerning the distribution of the stars in the galaxy but shows how the work in progress and the data which will become available in a short time will make it possible to build up a definite working model of the galaxy.

This volume is the first of a series of Astrophysical Monographs sponsored by the editors of the *Astrophysical Journal.* Other volumes are in preparation: one concerning the masses of the stars by H. N. Russell and one concerning stellar structure by S. Chandrasekhar. The editors intend these monographs to make "a rapidly growing library of precise, up-to-date, authoritative material on modern astronomy and astrophysics." G. V. B.

Celestial Globe, produced by Rand McNally and Company, New York, Chicago, San Francisco.

The Celestial Globe referred to above is a useful and attractive one. It has a number of features which are very commendable. In the first place it is of convenient size. The globe is nine inches in diameter and with its support weighs less than three pounds. It therefore occupies little space and is easily carried from one place to another. In the second place, the base and support and horizon circle are made of bakelite, of a color resembling highly polished wood, giving it a neat and finished appearance. In the third place the globe is mounted so as to permit of the various settings which may be required by the different latitudes in which the globe is to be used. In other words, the diurnal celestial motions may be represented by it as they appear to an observer on the equator or to one at the north or south pole. In the fourth place the constellations are delineated on a dark blue field, simulating their appearance on the night sky. The names and outlines of the constellation figures are clearly portrayed also. The essential circles, meridians, equator, and ecliptic, with appropriate graduations are easily seen. Fin-

ally, the price of the globe, considering its fine quality, is extremely low. The globe is obtainable with or without the horizon circle, the former for the retail price of five dollars, the latter for three dollars and fifty cents. The rich polish and finish of both the globe and support make it sufficiently decorative for any room. Because of the general interest in the stars, its presence in the home will raise many questions concerning the stars, and also answer them.

As a supplement to the use of the globe a pamphlet entitled "An Introduction to the Stars" accompanies each globe.

In a word, the possessor of such a globe and pamphlet has at his disposal all the equipment necessary to enable him to become familiar with the sky and to make the stars his abiding friends.

Le Faisceau Energétique Terrestre, by Dr. G. Froin. (Librarie Louis Arnette, 2 Rue Casimir-Delavigne, Paris.)

The book bearing the above title bears as an explanatory title also, Light and Color, Heat, Electricity, Magnetism, Radioactivity, X-rays, Planets, and Bode's Law. This range of subject gives the author a large region to cover. Although the reviewer has not read the volume completely he received the impression that the several topics are not treated in the conventional manner, but that much new and sometimes speculative thought has been introduced. A brief quotation from the *Addendum* will serve to show how different from common thought is the author's point of view. ". . . we do not see the sun or the stars and not even the moon, all being submerged in an obscure material which is impenetrable to our eyes." It is stated that we see phenomena which are not more than about 800 kilometers from the surface of the earth, and that the solar, lunar, and planetary discs are merely images, of reality however, in the atmosphere.

The author, from the description given, apparently is a physician. At the close he refers to a volume to follow this one which is addressed to biologists and physicians. Indeed he asserts, "The key which is to open the temple of secrets of biology and pathology is found." C.H.G.

Galaktischer Atlas, by K. F. Bottlinger and Irmgard Beck. (Julius Springer, Berlin, Germany. 15 marks.)

As the title clearly implies, this is an atlas of the sky in terms of galactic coordinates. The need for such charts is felt by all who make investigations relating to the structure of the sidereal system, since the galaxy is fundamental in this system. On the charts is delineated also, though less prominently, the equatorial system of coördinates, thus making it easy to determine at once both sets of coordinates for a given celestial object. There are six large and two smaller charts covering the entire sky.

Accompanying the charts is a pamphlet of eight pages the principal part of which is a table which transforms equatorial coördinates into galactic coördinates. The right ascensions are tabulated at thirty-minute intervals and the declinations at ten-degree intervals. The charts and pamphlet come in a neat and compact protecting case convenient for use.

The publishers and the authors are to be commended for issuing such an aid to astronomical work, as the probability of large sales, because of the technicalities involved, could not be an incentive. C.H.G.

Note: Due to unforeseen delays the plate of the photograph of the American Astronomical Society at Williamstown, intended for this issue, will appear in the following one. Ed.

POPULAR ASTRONOMY

CONTENTS

NOVEMBER, 1937

EARLY AMERICAN OBSERVATORIES, Willis I. Milham 465

THE BROWN UNIVERSITY ECLIPSE EXPEDITION TO PERU, Charles H. Smiley 475

E. P. BURRELL, J. S. Plaskett 478

THE TWO HUNDRED FIFTY BRIGHTEST STARS, Frank B. Lindsay 481

A TOTAL ECLIPSE OF THE SUN, JULY 29, 1878, James H. Freeman. 491

Planet Notes 492
Planet notes for December, 1937.

Asteroid Notes 493

Occultation Predictions 494

Comet Notes 495
Periodic Comet Encke, — Comet Whipple (1937 *b*), — Comet Hubble (1937 *g*), — Comet Van Biesbroeck (1935 *d*), — Periodic Comet Gale (1927 VI).

Meteors and Meteorites 496
Meteor notes from the American Meteor Society: Fireballs of 1937 June 14; Dual observations of five meteors,—Contributions of the Society for Research on Meteorites: Additional notes on the question of living bacteria in stony meteorites; Australites, Are they glass meteorites?; A course in meteoritics at the U.C.L.A.; The spelling of "Widmanstätten Figures."

Variable Stars 508
Variable star notes from the American Association of Variable Star Observers.

Notes from Amateurs 512
Quick method for conversion of standard time into sidereal time,—Amateur astronomical society of New Haven,—The Cleveland Astronomical Society,—The T-term in formulas of elements and constants.

General Notes 517
Personal notices,—Auroral display observed at the McDonald Observatory,—New American planetarium for Springfield, Massachusetts.

Book Reviews 519
Man in a Chemical World,—The Distribution of Stars in Space,—Celestial Globe,—Le Faisceau Energétique Terrestre,—Galaktischer Atlas.

Note 521

The principal articles of this magazine, beginning with Volume 15 (1907), are listed in the International Index To Periodicals.